MATERIALS & METHODS

THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE

Sodium Hydride Descaling
Glass as an Engineering Material
Pressure Vessels Made with Welded Nickel Alloy Linings
Porous Chromium Plating Adds to Piston Ring Life
Electrical Equipment for Spectrographic Analysis
Precision Production of Steel Aircraft Gears
Rapid Baking of Foundry Cores
High Speed Heating with Gas

Impact Extrusions
—Materials & Methods Manual No. 15

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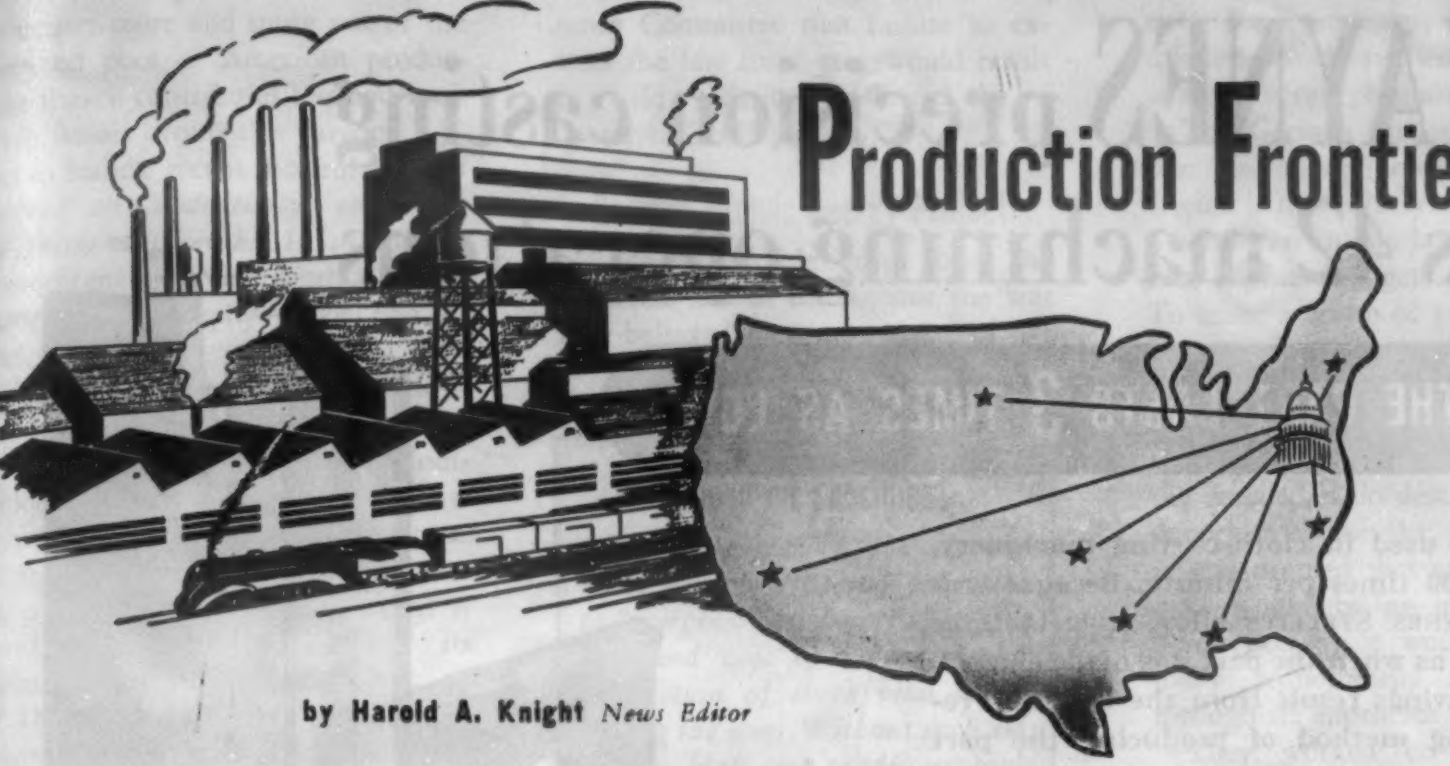
This month's Materials & Methods Manual deals with Impact Extrusions, so for our cover illustration we have chosen a few samples of this method of production. The Manual starts on page 1323.

NEXT ISSUE:

Alloys for High Temperature Service
Tri-Alloy Bearings
New Heat-Resistant Plastic
Heat-Treated Rivets
Welding Multi-Layer Vessels
Rapid Metallographic Polishing
Chromium-Vanadium Carburizing Steel "6120"
PROCESSING EQUIPMENT FOR PEACETIME PRODUCTION:
"Materials & Methods Manual" No. 16

RP REINHOLD



Production Frontiers

by **Harold A. Knight** *News Editor*

Remember the plow-under, kill-off days? . . . Now we're at the opposite end of the scale . . . How can we break production records with labor as is? . . . Daily stint for bricklayers was 1000 bricks daily; now 500 . . . Ford says plant efficiency is off 34% . . . Bureau of Labor says labor costs rose 50% from 1941 to 1944 . . . Even Stalin says: "Everybody in Russia must work" . . . If we apply to peace what we did to war, we'll win.

C. E. D. asks, however, whether high production is sole guard against inflation . . . Even majority of hard-boiled industrialists want price controls extended . . . Porter says no price control means "wild inflation, then paralytic collapse" . . . German atomic research practically stood still—same in 1945 as in 1943 . . . They did not envision a bomb but uranium power machine . . . Their atomic key men better Nazis than scientists . . . Funny, they thought they were ahead of the Allies.

Marginal metal mines again subsidized . . . Cartoon: the plastics man . . . Industrialists have caught up with basic facts of "pure" science . . . Cobalt is a Cinderella who won the Fairy Prince . . . Don't waste much time on the "Turbo-Encabulator" . . . "Operations Frostbite".

Our Economy Revolves Around High Production

The country has proceeded far (in what direction?) since those naive days when we plowed under the pigs and killed the corn (or was it the other way around?). We recall an anecdote which showed the confusion and topsy-turviness of those days. It seems that a city slicker was sent into the rural districts to help plan what should be plowed under and what slaughtered.

Now, at a certain farm he observed what were actually goats, but he had never seen such animals before and was highly puzzled as to what course to pursue. So he sent the following telegram to his district chief:

"ON FARM A SECTION B THERE IS A LIVING THING RUNNING AROUND WITH A LONG WHITE GOATEE STOP SHALL I ORDER KILLED".

Quickly came back a reply by wire: "GAD NO STOP THAT'S THE FARMER YOU'RE TRYING TO HELP".

Today, of course, our Government officials worry nights how hog and corn production can be increased, and they are feeding the farmer, mentally at least, vitamin pills so he'll have the energy to produce more. The plow under-kill movement has gone down in history as one of the famous fakes, like the Cardiff giant, the Mississippi bubble, and certain circus freaks.

Production—and more production—is the slogan of the hour. It is regarded by the economic and political doctors as the best guard against inflation.

Labor Efficiency: Now and in the Past

One important factor governing the rate of production is the attitude of labor. Edgar M. Queeny, chairman, Monsanto Chemical Co., recently made some interesting comments along this line. He said:

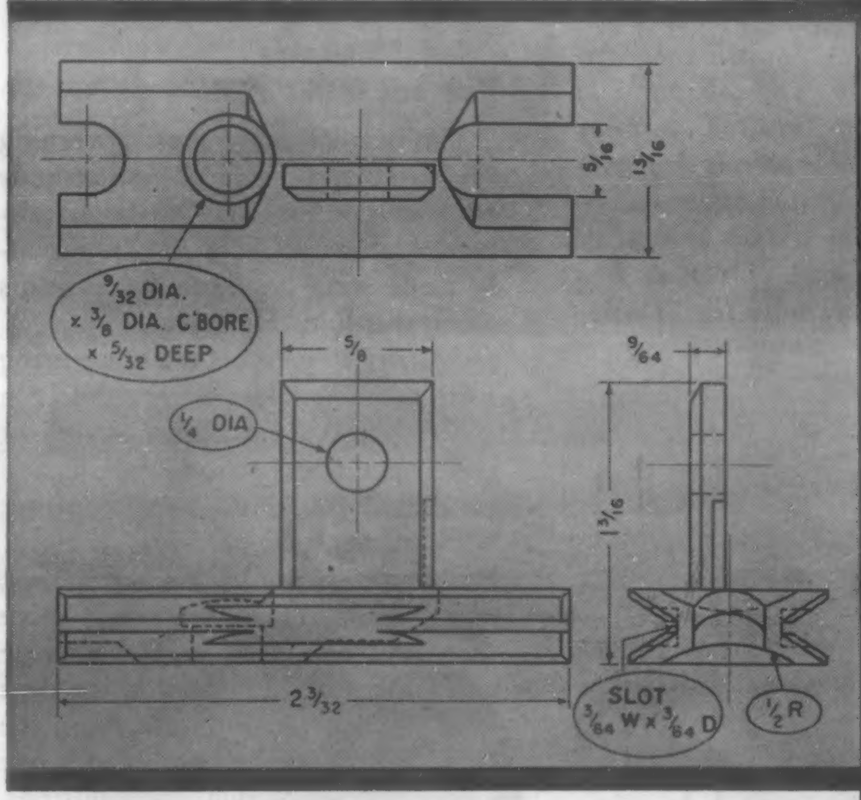
"American workers are not putting forth as much effort as they did even a decade ago. It is noticeable in our own operations though we lack a good yardstick. Ford says his plants' labor efficiency is off 34%. Walkers' Building Estimators' Book for 1931 lists bricklayers as averaging more than 1000 bricks a day. The estimate used on the building now rising next door was 500 bricks daily. From the U. S. Bureau of Labor Statistics one gleans that in 24 non-war industries, decreased efficiency coupled with increased wages raised 1944 labor costs 50% over 1941.

"Several generations of trade unionism in Britain have caused the denaturing of the nations' industrial keystone, its coal industry. In consequence, British homes are cold. Their industrys' fuel is costly and rationed. And if America is not already sending 'coals to Newcastle', she is actually delivering it next door.

HAYNES precision casting saves 42 machining operations

AND THE PART LASTS 3 TIMES AS LONG

This slide, used in cloth-cutting machinery, oscillates 3,600 times per minute. Because it is made of HAYNES STELLITE alloy, it lasts three times as long as when the part was made of steel. Additional savings result from the HAYNES Precision Casting method of producing the part because only 4 grinding operations are required to finish it, as compared to the 46 machining operations and heat treatment that were necessary when the part was machined from bar stock. This part indicates some of the design features that can be obtained from quality alloys through HAYNES Precision Casting.



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"How is it possible for everyone to extract more and more out of the common pool of American production if each contributes less and less? Even Russia avoids this paradox. Listen to Stalins' recent dictum! '*Wages depend on productivity: everybody in Russia must work!*' It is curiously reminiscent of Nineteenth Century American philosophy—'root, hog, or die'.

"On the more hopeful side—American temper and genius, molded during a century and a half of individualism, built a dynamic industrial structure that has great momentum. It may be able to hurdle all obstacles to complete its tasks of peace as it hurdled obstacles to complete its tasks of war".

There is one school of thought that high production is not the one panacea against inflation. States a recent report from the Committee for Economic Development:

"We look forward to a further expansion of production and must do everything possible to hasten this expansion. But it is not clear that production increases will of themselves, in the near future, eliminate the excess of demand. Expanding production will bring higher incomes, increased bank credit, and general optimism, and it might conceivably increase rather than decrease inflationary pressure".

Shall Price Control Be Expanded?

All recognize that the future course of our economy is linked closely with our price control policies. The general proposition on which majority of opinion agrees is that price control shall be lifted the moment that supply and demand balance.

An industrial publication recently took a poll among the executives of large industries. The result announced was 53.8% in favor of controls beyond June 30, 1946. Even among presidents and chairmen of boards 47% were for continuing controls. Production managers were 65% in favor of keeping price ceilings.

The publisher of that journal expresses the opinion that his poll represents a good cross section of the National Association of Manufacturers and that the officers of that organization are advocating the opinion held by a minority of their members.

Paul Porter, the new Price Administrator, told the Banking and Currency Committee that failure to extend the law for a year would result in wild inflation, followed by a "paralytic" collapse.

German Atomic Energy Project

"The remarkable thing about the Germans is that throughout the war they believed they were ahead of our effort in nuclear fission developments. Not until the news broke that the atomic bomb had been dropped did they realize that they were behind."

So writes S. A. Goudsmit, professor of physics at the University of Michigan, associated with the radiation laboratory of Massachusetts Institute of Technology during the war, in the *Bulletin of the Atomic Scientists*. Prof. Goudsmit led a scientific mission which studied the German atomic energy program.

The German line of thought was that an energy-producing uranium engine is more likely to succeed than a bomb; an atomic bomb is an uranium engine that gets out of control. To make a bomb of pure plutonium never entered their minds. The idea of using a "pile" to produce plutonium and to make bombs out of that material didn't occur to them until the detailed radio descriptions of the American bomb in August, 1945. It was deemed that an uranium engine would be as important as a bomb because it would make Germany economically self-supporting through its enormous power.

They worked on nothing else, therefore, except to build what is called in the U. S. A. a "pile", or uranium machine. But they made progress with extreme slowness. At the start of 1945 most of the research was still in practically the same state as it had been in 1943. Isotope separation had been tried on only a very small scale by means of a centrifuge.

German scientists knew practically nothing about Allied developments aside from what they had picked up in the summer of 1939. During the war they received some utterly wrong and useless information obtained from travelers or other doubtful sources.

The Germans worked hard on the "pile". By the end of the war they had merely come to the conclusion that a heavy water pile was possible. They never did construct a self-containing pile and had not produced a chain reaction. They were not aware of numerous new difficulties they would have encountered if they really had progressed at building a pile.

German scientists lacked vision and did not believe in success from the beginning. They did not believe that nuclear fission could be developed in a practical way within a reasonable time. Moreover, men in administrative positions were utterly incompetent. The chief adviser for German Ordnance was a second rate physicist, Schumann, and his helpers were inferior compared with scientists available. Several groups worked independently.

There was finally coordination of effort after disastrous German defeats in Russia and disappointing subma-

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Phooey on Subsidies!

Since early 1942, the Government has been paying premiums to "marginal" producers of copper, lead and zinc to induce greater production of these vital metals during the war. Without such aids certain high cost producers could not have stayed in business. The original law was to expire on June 30, 1946. The Office of Economic Stabilization recently announced that subsidies will be extended for another year to compensate for recent wage increases.

We sat in recently with a representative group of these same metal producers, and none favored subsidies—they wished instead for lifting of ceiling prices to true world price levels, which are considerably higher than our ceiling prices of 12 cents per lb. for copper, 6½ cents for lead and 8¼ cents for zinc.

Commenting on the extension of metal subsidies, the N. Y. Times *says: "Here we have one of the most dubious of all the elements in the Administration's wage-price policy. There is no surer way to accelerate demands for further wage increases and to accentuate the pressures for inflation than this effort to maintain the fiction of price stability in the face of large wage increases. The subsidy has long outlived its usefulness".*

Test of Quality

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Try This on Your ROLLING AND BENDING MACHINES

Cross-sectional contour.

This moulding with intricate cross-sectional contour and a 90-degree corner bend was roll-formed from Sharon Stainless Type 430 (.018 gauge), a straight-chromium grade.

Stainless Steels

HOW WELL a stainless steel performs in actual fabrication is usually accepted as a true test of its quality. That's why Sharon Stainless is recognized as a high grade product.

In the case of the moulding, illustrated above, the fabricator requested a straight-chromium stainless steel that would bend flat on itself in the direction of rolling, then bend round to form a 90-degree corner angle.

Sharon Stainless solved the manufacturer's problem by enabling him to fabricate satisfactorily a moulding that met design and service specifications.

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rine warfare. Finally one man, a competent scientist, was placed at the head of the whole organization in 1943. There was a dearth of available scientists, since many had been drafted into the Army. In 1943 key scientists were taken out of the Army and placed back into civilian work, though the bulk remained in the Army, many having been killed. Too often leaders of scientific organizations were incompetent Nazi political henchmen.

In 1939 Schumann went to France and tried to move the French cyclotron to Germany but finally decided to move Germans to it and make it work at its original site. The best-qualified groups were the Kaiser Wilhelm Institute for Physics in Berlin, under Heisenberg, and the physics section of the K.W.I. for Medical Research, in Heidelberg, under Bothe. These two men made a survey trip through the United States in the summer of 1939.

At the start of the war, von Ardenne, a clever technician and business man, was considered by the Nazi authorities to be the real expert on the uranium problem, much to the dismay of the competent scientists. Various groups worked in competition with one another.

The coup de grace of the Allies was the bombing of the heavy water plant in Norway just when it was nicely started on production. This left so small a supply that the various scientific bodies quarreled over who should have priority to experiment with it. More intensive bombing of Germany forced the scientists out of the big cities and into small villages where equipment was scarce and crude.

Some of the key scientists were not allowed to give concentrated time, but did much teaching and administrative work. After the Norwegian heavy water plant was destroyed, attempts were made to have the German chemical industry produce heavy water. However, this did not succeed. Uranium metal was produced in quantities sufficient for only small scale experiments. Perhaps 100 scientists, scattered throughout Germany, were working on nuclear fission.

German security provisions were not of high standard. Typical, were letterheads such as the "Plenipotentiary of the Reichsmarshal for Nuclear Physics". However, locations to which laboratories had been evacuated were kept very secret. Toward the end of the war German experiments had indicated that it was possible to obtain an increase in the number of neutrons, but no self-sustaining neutron source had been constructed as yet. They believed, however, they were far ahead of the Allies and might dictate a favorable peace even if military developments were unfavorable.

Bormann began to boast in such a cocky and exaggerated manner that the scientists were much disturbed. There was much talk of locking up all scientists in remote sections of Bavaria to better concentrate on experiments, but actually only one small group was kidnapped by the S.S. and taken there.

More on "Pure" Science

During recent years there has been considerable discussion as to relative importance of pure science and applied science. It has been said, for instance, that during peace pure scientific facts accumulate and form a reservoir that is tapped during a war. Moreover, during combat there is no time to make progress in pure science.

Somewhat along these lines, Dr. Charles Allen Thomas, Monsanto Chemical Co., talked before the annual stockholders' meeting of his company. "Our universities have become exceedingly interested in conducting industrial research in the last decade", he said. "I have no quarrel with this, particularly as it offers professors a closer contact with industrial problems. But if this interest is crowding out the universities' primary role of fundamental research and training, it may be extremely detrimental to the future of our nation.

"Industry today is catching up with fundamental knowledge and is becoming anxious for more basic facts. Unless this knowledge is available within a reasonable time the whole field of organic chemistry and its numerous allied fields will be slowed down.

STRESS RELIEF

"J. P., this is Mr. Smathers of Transparent Plastics."

"One point seems obvious, that specialists can have over-specialization and that a highly scientific education often makes a narrow man. It is important that the scientist have a better realization that others, outside the world of science, have much to contribute to life and living.

"There is a new appreciation of the great gap between the technologist and the fundamental scientist. Industrialists need to have a greater understanding of fundamental research and a deeper understanding of this fountainhead from which all industrial applications must spring. One of the great problems in running an industrial laboratory is to prevent our technical men from growing stale. They need the contact of the academic circles to stimulate their thinking. Perhaps we should encourage our men to return to the campus for refresher courses.

"We need engineers with a broad scientific training and not men who with handbook and slide rule alone attempt to solve all of life's problems by fitting only the known factors into an established formula".

Cobalt—From Rags to Riches

Cobalt became an extremely important metal during the war. Besides the older uses in high-speed cutting tools in the alloy composition of "Stellite", it was used in place of silver in reflectors of searchlights by the Navy and over 25,000,000 turbosupercharger buckets in airplanes were made of an alloy containing as much as 65% cobalt. More recently, it has been used in the atomic bomb development at Oak Ridge, Tenn. It is used in radar, in powerful magnets, rust-resisting steels, etc.

The metal has an interesting history of ups and downs. It was a mystic, untouchable metal in the pre-Christian era. Glass and ceramics in ruins of early Rome and Egypt are found to contain cobalt as color pigment. It was named "kobold" (goblin) by early German alchemists.

However, found in association with silver, cobalt was often regarded as a nuisance because of effort needed to separate from silver. But cobalt is now worth 80 cents to $1.00 per lb., and demand is greater than supply.

The greatest North American deposit, at Cobalt, Ont., was discovered in 1903 when Fred La Rose, a railroad worker, threw his hammer at a thieving fox, missed, chipped a piece of rock that was almost pure silver from the railroad cut and started a rush for riches that rivaled the Yukon and Klondike strikes.

The early miners were wasteful, and tremendous wealth was lost in tailings that is now being recovered. There is now considerable revival in mining in the Cobalt district. The Silanco Mining & Refining Co. is building the largest smelter and refinery of its kind in North America, having twice the capacity of a similar smelter built at Cleveland during the war by the United States Government.

The early miners took out silver without benefit of engineering, and followed the rich veins wherever they led. Once they followed too close towards a lake bottom, set off a blast and blew a hole in the bottom. This hole had to be repaired before the Silanco pumping operations could start. They dammed the lake on both sides of the break and pumped the lake section dry.

Cobalt, Ont., a ghost town for 22 years, is alive again. Young men, returned from the war, are operating drills, muckers, ore cars and hoists. So much for Canadian activity.

Meanwhile, the U. S. Bureau of Mines has just published a pamphlet on "Metallurgical Treatment of Cobalt Ores from Goodsprings Mining District, Nevada". It describes studies designed to increase production from low-grade western deposits, and deals with the leaching, flotation and electro-winning processes.

The Turbo-Encabulator

A month or so ago we received a little pamphlet from Arthur D. Little, Inc., Cambridge 42, Mass., entitled "The Turbo-Encabulator." We read it and contorted our face in an effort to comprehend its every meaning. We filed it away in a folder, undecided whether to reproduce it in this department. A few weeks later we, with other technical press editors, were guests of the Haynes Stellite Co. at the Elks Club, Kokomo, Ind. One of the speakers read this pamphlet. It was well received. So, we've decided to publish the first two paragraphs and the last. Get out your dictionaries!

"For a number of years now work has been proceeding in order to bring perfection to the crudely conceived idea of a machine that would not only supply inverse reactive current for use in unilateral phase detractors, but would also be capable of automatically synchronizing cardinal grammeters. Such a machine is the "Turbo-Encabulator." Basically, the only new principle involved is that instead of power being generated by the relative motion of conductors and fluxes, it is produced by the modial interaction of magneto-reluctance and capacitive directance.

"The original machine had a base-plate of prefabulated amulite, surmounted by a malleable logarithmic casing in such a way that the two spurving bearings were in a direct line with the pentametric fan. The latter consisted simply of six hydrocoptic marzelvanes, so fitted to the ambifacient lunar waneshaft that side fumbling was effectively prevented. The main winding was of the normal lotus-o-delta type placed in panendermic semi-boloid slots in the stator, every seventh conductor being connected by a non-reversible tremie pipe to the differential girdlespring on the "up" end of the grammeters.

"Undoubtedly, the turbo-encabulator has now reached a very high level of technical development. It has been successfully used for operating nofer trunnions. In addition, whenever a barescent skor motion is required, it may be employed in conjunction with a drawn reciprocating dingle arm to reduce sinusoidal depleneration."

"Operations Frostbite"

We are intrigued by our Navy's designations of various fields of operations and are contemplating applying them to our own humble editorial work. We try to balance the subject matter in M & M so that every materials and metals field is covered in proportion to its importance. For instance during the past two years we have published five articles on sub-zero treatment. Borrowing from the Navy, suppose we classify these as "Operations Frostbite". (The Navy so designated maneuvers in Arctic waters.)

Then we have certain engineering articles where key or focal points are where the abscissa cross the ordinates in a chart or diagram. How about "Operations Crossroads"?

And for the many heat treating articles. Would "Operations Hot-Foot" suit the Navy—and us?

EDITORIALS

Dog Eat Dog?

One of the modern phenomena in the materials field is the growth in number and activity of trade associations promoting individual types of materials. If the Copper & Brass Research Assn. are doing all in their power to promote the use of copper; Lead Industries Assn., Inc., ditto for lead; the Magnesium Assn., a second ditto for "mag."; the American Iron & Steel Institute, the Society for the Plastics Industry, etc. the same for their materials, ad infinitum, where will it all end up?

The war is over and slick competition rules the business and industrial world again. Theoretically, if all material-promotion organizations are equally competent and push with equal force against the wall of consumer resistance, the contest will be a draw, with the same results as though no trade association had ever been formed. Perhaps the newly formed trade associations are merely a case of "keeping up with the Joneses." Perhaps it would be best for engineering materials trade associations to form a U. N., so to speak, and straightway agree to disband their organizations and cease promotion work.

These promoting associations are sometimes classed with advertising, and it will be recalled that during the war some bright boys in Washington, with leanings toward the left, sought to abolish advertising, calling the advertising profession parasites and non-creators of wealth.

But no—a thousand times no! Trade promoting associations are parasites only if school and college teachers are parasites. After all, a good trade association cannot ultimately ram a certain material down the throat of a consumer. The promoting organization is merely a school that teaches the facts and good points of that metal or material to the wide, wide world.

No matter how much "promotion," the material in the long run must stand on its merits. Apparently concerted competitive efforts on the part of rival materials increases the overall consumption of all materials. The world learns more about materials and acquires a taste and desire to possess more tools and luxury items made of those materials that makes life less drudgery and more pleasant.

Theoretically, only one material or combination of materials is best for any one particular job. The more promotion, the more "propaganda," the sooner the consumer can correctly weigh and appraise that one best material for each application. And the more accurate that propaganda, the happier everyone will be in the end!

—H. A. K.

Lost Knowledge

There is a good chance that at least one-third of the technical knowledge gained during World War II will be lost. Actually, there is no way of proving such a statement. It is an estimate based on this one observation: Due to poor, incomplete recording and cataloging of the technical information acquired during the war, about one-third of it will be lost for future reference.

There is no doubt that an honest attempt was made by Government agencies and industry—and technical magazines—to write-up the progress of all their technical activities. Thousands and thousands of reports were written, many, indeed, at the drop of a hat. Too many, however, failed to do a good, accurate job of reporting. They were thrown together without much thought, often incomplete, inaccurate, and obscure. As an example, while reading an NDRC report on a fairly easy subject, the question, "What does the writer mean?", popped into our heads exactly nineteen times. The report was ten pages long (not including appendices). Another report put out by the Army contained 29 pages of graphs and tables and only two pages of writing. In those two pages the author made a feeble attempt to explain the curves and figures, what they meant, and where they came from.

These two examples are not isolated cases; they are representative of a great many war-born reports, which to be useful must be interpreted by their authors. When the authors die, that knowledge will be buried with them.

What can be done about it? Unfortunately, not much. Poor and incomplete writing cannot be undone, but we can make sure not to repeat the same mistakes. We can resolve to do a better job of technical writing from now on. Every engineer, every company, every technical organization (yes, and every magazine), should assume the responsibility of accurately, completely and clearly recording the details of contemporary technical achievements. —H. R. C.

The Arkansas Traveler

An outstanding characteristic of "good times" is increasing unit costs. When business is prospering (during "good times") a manufacturer's labor costs rise noticeably, labor efficiency decreases (jobs are easy to get), sales increase, marginal machines and processes become profitable, and production equipment, because it is utilized longer hours or at greater levels of output, wears rapidly. But profits are being made, so it is difficult to justify the purchase of newer and more efficient equipment. Management questions the advisability of discarding a machine that is operating at a profit. In other words, why spend money "needlessly"?

Would the expenditure for new, more efficient processing and fabricating equipment be "needless" while the presently employed machinery still shows a profit?

Let's look at the other side of the picture. If increasing unit costs are a characteristic of prosperity, decreasing unit cost are just as certainly a trend during "bad times". There are not enough jobs for everyone, consequently the over-all efficiency of labor increases as workers compete to hold their jobs. Prices tend to be depressed as the level of business activities spirals downward. Marginal methods and equipment are no longer used. Machines and factories that formerly operated at a profit (however small it may have been, it *was* a profit) are now "running in the red". People say that these non-profit making devices and processes are "obsolete". As a corollary to this, we may say that manufacturing machinery and methods tend to become obsolete during "bad times".

The question, then, is—if equipment operating at a profit cannot be written off the books and replaced because it still has "life", or has not been completely depreciated, during the "good times", and then during "bad times" there are no profits to use for purchasing more efficient, streamlined equipment, when is the opportune time for buying, and installing, new manufacturing machinery?

The answer may be with the accountants and the tax-law-makers. If accountants had some factory operating experience or would listen to the factory managers, their conception of "obsolescence" might be more realistic. And if shorter statutory depreciation periods (for tax purposes) for processing machinery and factory equipment were permitted, our definition of "obsolescence" as applied to both factories and equipment could be revised to render it more practical and workable.

Then, perhaps, there would be a meeting of minds of the management and operating staffs and, as a result, worn or technically obsolete machinery could be replaced during "good times" when the new piece of equipment might help to lower or level off unit costs. Then, when industrial activity declines, efficient and labor saving devices (being already installed) would permit factories to operate at a profit or at a smaller loss during the inevitably subsequent "bad times".

If industry, like the Arkansas inhabitant, neglects to mend its roof on a sunny day because it is not leaking then, it will not be able to weather the rainy days to follow and the nationalization of industry will ensue. —R. S. B., Jr.

RESEARCH

That seeks and develops new and better products

• Inland metallurgists continually strive for perfection, a goal that can never be fully attained. Theirs is a constant search to obtain from the materials and the furnaces improved results in the making of Inland Steels.

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AN EDITORIAL

Better Plowshares Follow the Swords

The state of suspended animation in which this country's industry has floated since the war's end has been "activated" to any notable degree only in the last few months, and many large segments of our economy are still far from busy. But already it is clear that (1) our new peacetime products are going to be much better than their prewar counterparts, because of materials engineering progress during the conflict, and (2) every last increment of newly developed processing methods knowledge will have to be applied to our production if the challenges of meeting competition, and of achieving real mass production (and thus defeating inflation) are to be met.

The Materials & Methods Achievement Award (see our January issue, page 79) is to be conferred this year specifically for just such achievements as these—for the best application of war-developed knowledge of materials and their processing to the manufacture of peacetime products. A number of possible contenders are already in evidence—the use of new high-temperature steels and alloys, developed for jet engine and related applications, in steam and other "peaceful" high temperature equipment; the applications of atomic-bomb diffusion barrier materials in process-industry equipment; the development of railway equipment utilizing the new super-strength aluminum alloys; significant application of magnesium alloys in automotive parts; a host of peacetime uses for new plastics; and several outstanding uses of individual new heat treating, finishing, welding, machining, forging, forming and casting methods to lower the cost, improve the quality or increase the production capacity of various new peacetime products.

But there are many other applications of war-time developments to peacetime planning that are of Award-winning stature but which may not come to our attention unless the individuals or companies involved tell us about them. We therefore urge everyone — developers, producers, and users of materials, those engaged in the sale or use of processes and equipment, and peacetime product manufacturing engineers in general—who have made or witnessed outstanding applications of war-developed materials or processes to peacetime products to communicate the general nature and location of the applications to us and we will promptly investigate the developments as to their possible eligibility for the Materials & Methods Achievement Award.

All outstanding applications of this type will receive publicity whether they win awards or not. Those who cooperate with us in suggesting award candidates, therefore, will not only be helping themselves, or their friends, or their customers, but will also aid tremendously in improving the quality or costs of the new products that American industry will start manufacturing at a really heavy rate in the next few months. That is a goal worthy of the collaboration of all!

FRED P. PETERS

Experience in stainless and alloy steel mills points to the use of this new process for many descaling, deoxidizing and skin softening tasks.

Sodium Hydride Descaling

by EDWIN LAIRD CADY

SODIUM HYDRIDE DESCALING of metals is a new process in which the metal is held in an open tank or vat filled with a mixture of caustic soda and from 1.5% to 2% of sodium hydride, at about 700 F ±20. When the metal to be descaled is immersed in this mixture, the oxygen-hungry sodium hydride reduces the oxides in the scale and thus turns the hard and clinging scale into a loose and flaky or powdery mass; the metal with its temperature raised to the 700 F found in the bath is taken from the bath and quenched in cold water, the water in contact with metal at this temperature forms steam blasts off the scale. Subsequent steps may include a dip in dilute acid, usually about 10% sulphuric, to neutralize any caustic remaining on the metal, and nitric or other acid dips for bleaching and passivating effects.

Twelve large scale installations of this process are in operation. The installations at Carpenter Steel Co. are unique in that they employ Ajax-Hultgren electric salt bath furnaces for heating the mixture of caustic and sodium hydride. In this equipment the caustic is heated by its own resistance to alternating current at low voltage. The electrodes are so designed and grouped as to create electromagnetic forces which provide automatic stirring action throughout the entire bath.

Exact holding of the temperature is important to this process. If the temperature gets much above the 700 F mark there is a costly loss of hydride. If the temperature gets too low then the coating of caustic which solidifies or freezes about the cold metal when the metal first is immersed in the bath will be slow to liquefy, the entire bath may be dragged down below its correct reaction temperature, and the process will be slowed down in production capacity accordingly.

Because the electricity responds instantly to changes in temperature within the bath, Carpenter Steel is able to run bath temperatures as high as 720 F in order to secure an extra large bank of heat for "fly wheel effect" when an extra large batch of steel is to be processed. They can do this because they know that their accurately controlled heating system will hold the temperature at that top point and not let it run higher into what might be wasteful temperature zones.

Together with the stirring action within the bath, this instant response of the electrical system permits Carpenter Steel to immerse enough metal at one time to drag the bath temperature clear down to 650 F. The stirring action brings fresh supplies of hot caustic to the metal surfaces upon which the caustic has cooled and frozen, results in rapid re-liquefying of the frozen caustic, and causes the entire bath with all of its bank of heat to share in warming up the metal to the bath temperature. In the meantime the instant responsiveness of the system is adding fresh supplies of heat at a rapid rate and is bringing the whole bath up to the desired 700 F.

Inserting a sodium brick in a generator unit.

All of this is done with heating elements and with temperature control actuating elements mounted at one side of the tank and out of the way of the work.

The ability of Carpenter Steel to take greater liberties with the exact maintenance of temperature than any other user of the process has announced itself as taking, is important to the finding of the limits of the flexibility of this process. And, together with the limitations upon many other factors, these flexibility limits need to be known.

Historically, the sodium hydride descaling process can be described as having been inhibited for about four years and allowed to grow for part of one year. It was invented, patented and developed by scientists of E. I. du Pont de Nemours and Company Incorporated, the principal interest of that company in it being a new field for the use of metallic sodium which the du Pont Co. produces in large quantities. No license is required and the process is royalty free to users in the U. S. The four year inhibition came from the fact that nearly all the metallic sodium which could be made during the war years was needed for other purposes, one of which was the making of airplane fuels.

Consequently, the process is in a development stage in which equipment and methods highly suited to the sizes and shapes of metal parts and to the sizes of production lots commonly found in stainless and other alloy steel mills have been worked out, but much adaptation may have to be done before it can be applied to some of the other types of plants.

Many Prospective Uses

Prospective uses exist by the thousands. They include such widely varied applications as descaling the welded areas at which I-Beams and other structural shapes are joined when prefabricating steel assemblies, descaling after heat treatment of intricate parts for aircraft, or taking the last vestiges of metallic oxides out of invested flasks when using low melting point metals as dispensible patterns in precision investment casting. Other potential uses include descaling the complicated forgings used in surgical instruments, descaling or deoxidizing after brazing, deoxidizing as a means of softening the skins of castings before machining and of loosening and removing sand particles which are embedded in their surfaces.

Engineers of the du Pont Company and of the various makers of heating equipment and control instruments are doing plenty of development work, but prospective users must base much of their thinking upon the experiences of the stainless steel and alloy mills which already have the process well in hand.

These mills have found that sodium hydride descaling has many advantages.

Sodium hydride descaling prevents the loss of from 2 to 3%, sometimes even more, of good metal which

Material ready for descaling. It will rest on supports within the tank.

formerly was eaten away in the pickling process. This is of obvious importance to a mill which is selling metal by the pound. It can be of equal value where the dimensions of bars or of heat treated parts must be accurate for high-speed high-accuracy setting up of machine tools for secondary operations, where it is desired to have close accuracy on unmachined surfaces, and where limitations upon the dimensions of parts compel working to such narrow factors of safety that any loss of metal in a pickling process is to be avoided.

The sodium hydride reaches, or can be made to reach, all surfaces to which liquid can flow. Descaling is uniform.

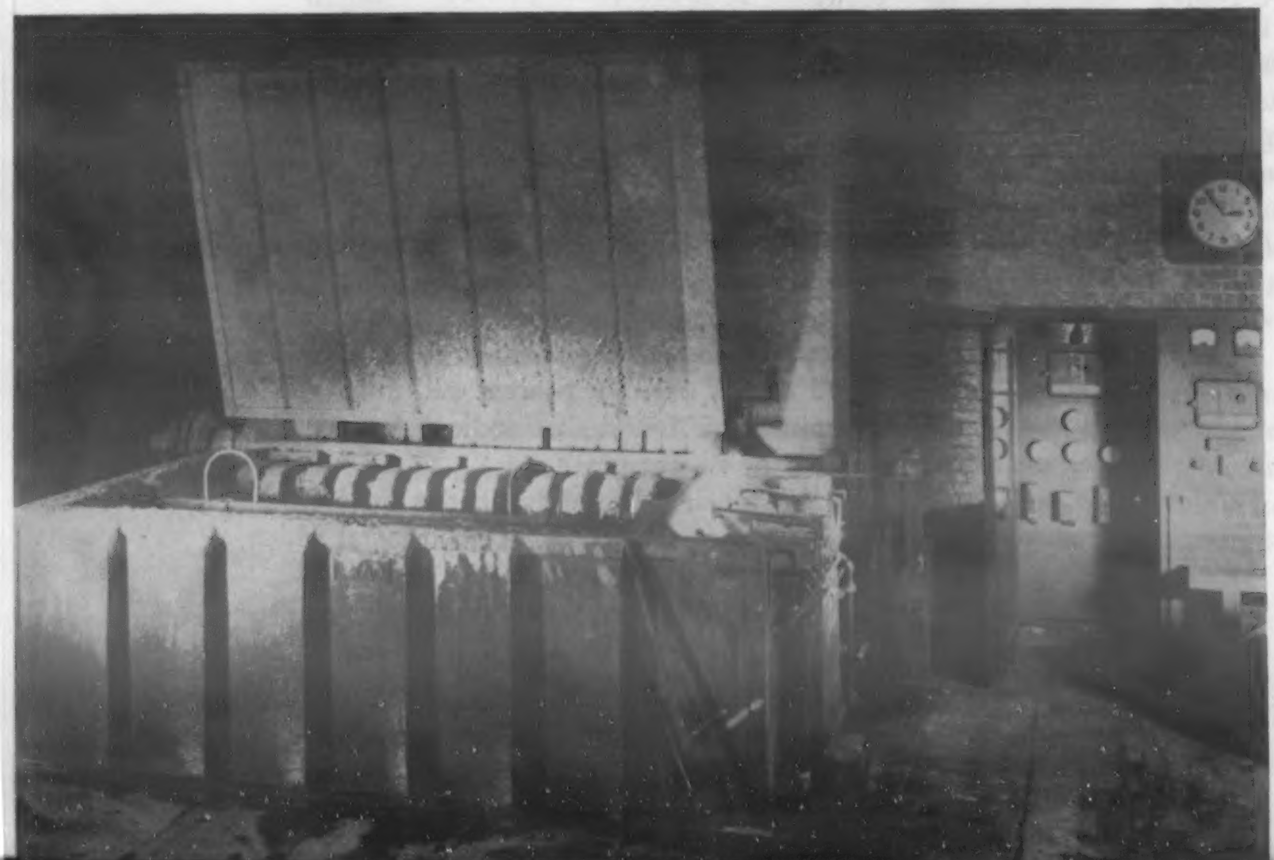
So long as the metal remains in the bath long enough to reduce the scale, usually from 10 to 12 min., it can remain there as much longer as desired. There is no danger whatever of over-pickling. One result of this is to modify the need for exact timing of scale removing operation cycles. If the men who run the operation are needed elsewhere or if some operation farther along the line is not yet ready for the immersed metal the metal can remain in the bath. The scale removing sequence thus is made more flexible. Another result is that complex parts having small recesses or severe undercuts can have their scale removed with much greater ease. One of the common troubles of pickling is the over-pickling of exposed surfaces while getting the scale off from the less exposed ones. With the sodium hydride process this trouble does not occur.

No mechanical cold working processes and no abrasive blasting ones for loosening the scale in preparation for scale removal are necessary. In the Carpenter Steel mill some kinds of wire formerly had to be run through scale breaking machines before pickling. These machines uncoiled the wire, put a double bend in it, and recoiled it. Two men running one machine could process about one ton of wire an hour. This cost has been eliminated, making the machines and men available for other uses. Moreover, the bending used to put slight but undesirable work hardening into such steels as 301 stainless, and this bother also is gone.

Pitting troubles have been reduced to the vanishing point. Pitting can have several causes. Among them are the tendency of acid to attack some tiny areas of bare steel more readily than others, the penetration of the acid through tiny breaks in the scale so it gets at some parts of the good metal before others and results in over-pickling of small areas, and the abrading of the metal surface by driving particles of hard scale into it during cold working and thus providing abrasions which the acid may attack more readily than it will smooth areas. The sodium hydride process itself will do no pitting whatever, and it will not set up any of the common causes of pitting for the acids in subsequent steps to work upon.

The sewage problem of disposing of spent pickle liquors is eliminated or reduced.

There is no hydrogen embrittlement of steel and no need to bake the steel to eliminate hydrogen from it.



Left: Electrodes are at the back of this descaling tank. The tank has an insulated cover which can be lowered to retain heat when the system is not in use. Control instruments are at the right.

Right: Excess of hydrogen burns at the vents. Generators are no more than 10 ft. apart.

Many Metals can be Processed

A wide range of metals can be processed. Alloys of chromium, copper, nickel, tungsten, cobalt all have been processed and so have plain carbon steels. Two or more different alloys can be processed at one time. The process is especially useful with combined or clad metals consisting of two alloys which if pickled would require entirely different exposure times to the pickling acid.

The time needed for removing scale is greatly reduced. In the Carpenter Steel mill the pickling time, all operations included, used to have a general range of 15 min. to 2 hr. per batch of steel depending upon such factors as the type of alloy, the hardness of the scale and whether or not mechanical scale breaking operations were needed. Now the time for actual scale removal is from 12 to 20 min. The average reduction of operational time is 50% but it can run much higher than that.

With all of its advantages, this process is not one to be set up and operated as casually as a plant might install a drill press. In industrial parlance sodium hydride descaling would be called a "process" rather than a "fabrication method" and it has some of the troubles common to process industries.

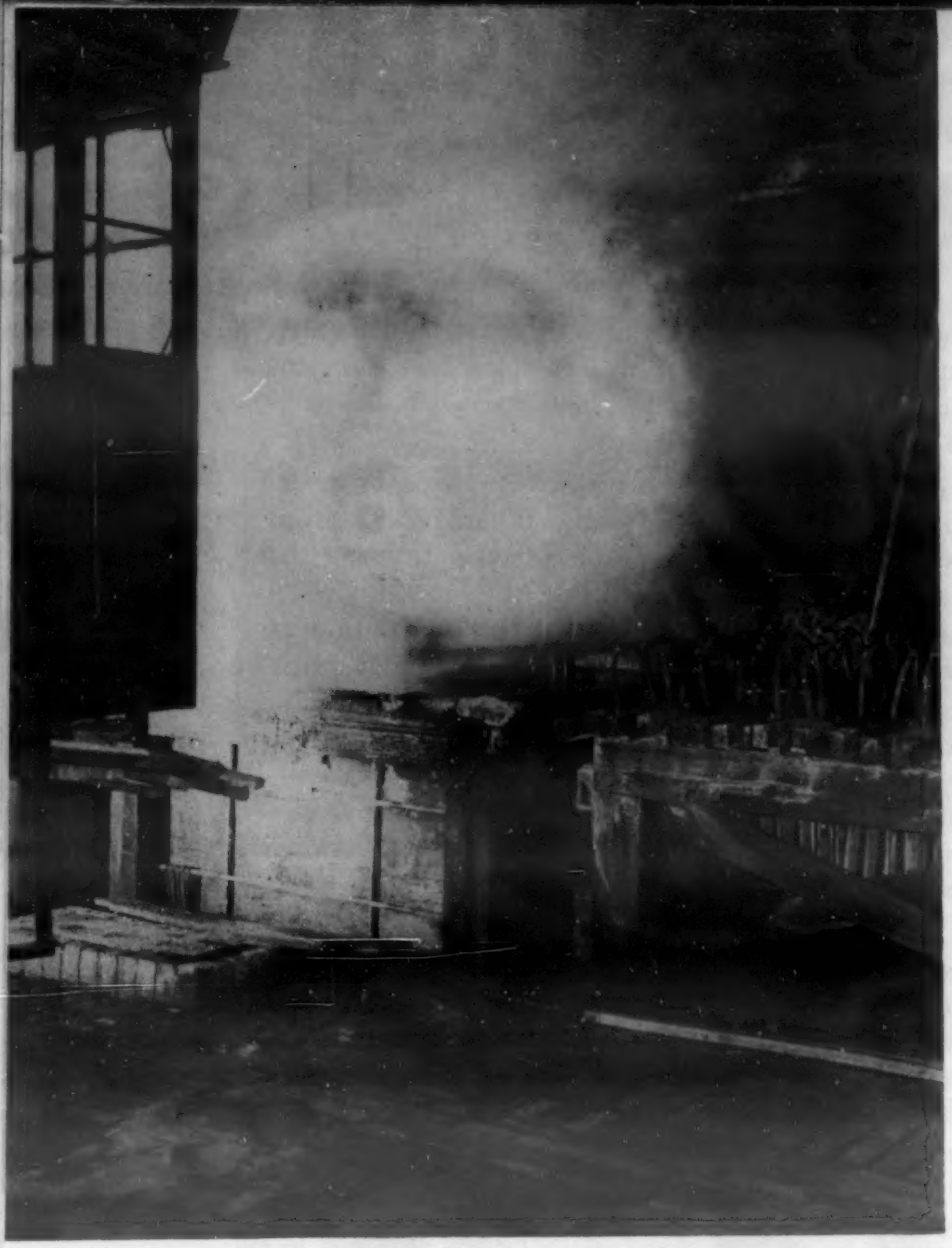
For example, once the caustic bath is heated it should not be allowed to cool to the freezing point. The only trouble which such cooling would cause would be that of reheating the caustic. In baths of the sizes used in steel mills that would be bothersome. Nevertheless the need to keep the bath hot at all times, in the face of possible plant shut downs or failures of power sources, will indicate to the prospective user one type of problem which he will have.

Of course, the process is capable of being operated on a much smaller scale than is needed for a steel mill. There are no inherent size limitations on the apparatus other than that the tanks shall have sufficient capacities to admit the batches of metal parts which will be fed to them and must hold enough caustic so the heat bank in it will prevent the temperature from going down too far when the cold metal is immersed.

The metal could be preheated, perhaps by recirculated waste heat from some other process, thus avoiding the cold shock problem and permitting the bath to be smaller for a given output of tonnage. Parts could be moved through the bath by continuous conveyor methods thus providing a continuous drainage of heat which could be compensated by continuous input. If various methods were used to reduce the size of the equipment for some of its possible uses—although probably not for steel mills—then a size might be reached at which cooling down between operations would be practical.

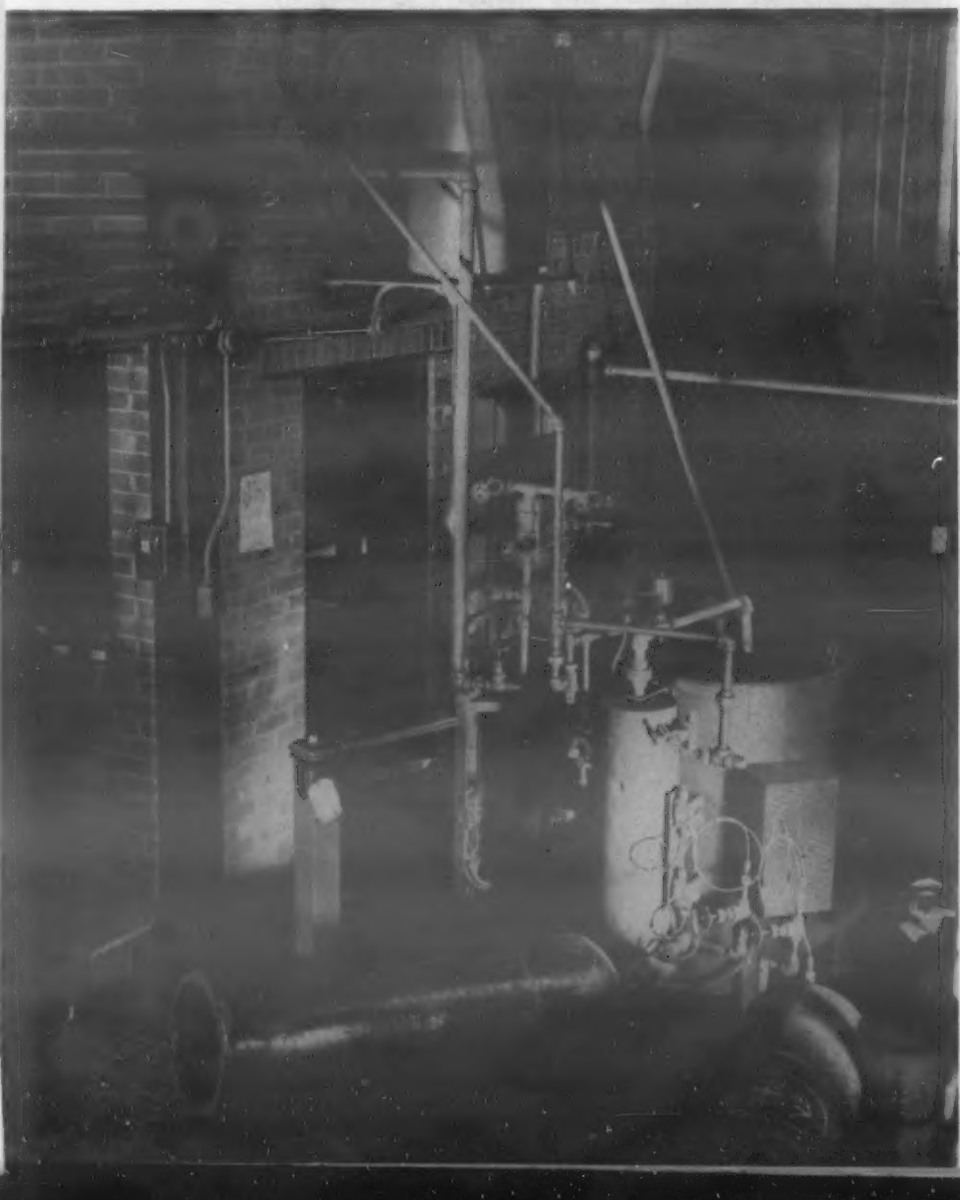
The sodium hydride is produced in one or more "generators" at each tank. A generator is itself a metal tank or box having one end open to the bath but below the surface of the bath—in the Carpenter Steel plant this opening is 18 in. below the bath surface—and one or more vents at its top. The generator is nearly filled with the same caustic that is in the tank. Through this caustic and within the generator, dissociated anhydrous ammonia gas is fed, bubbling up to the top. Bricks of pure metallic sodium are fed through the vents at the top. The hydrogen in the dissociated gas combines with the sodium to form sodium hydride. The sodium hydride feeds through the opening in the bottom of the generator and is dispersed through the main tank. The currents set up by the electrical stirring action of the heating mechanism in this installation help with this mixing and dispersal.

One generator will feed and disperse sodium hydride by this stirring action for at least ten feet in every direction in the bath. The Carpenter Steel Co. does not know whether or not this distance could be increased. The original installations here have two



Steam is formed when the heated metal is quenched in water.

Separated from the tank by a masonry wall and carefully guarded by a heavy wire fence are the ammonia equipment and most of the electrical apparatus. Ammonia flasks are kept mounted on scales so their remaining contents can constantly be weighed.



or more generators in any tank in which a single generator would have to disperse the hydride for more than 10 ft., and no experiments have been made with any longer spacings.

The hydrogen for this installation, as is likely to be the case with any large installation, is obtained by the cracked ammonia process. The ammonia equipment, together with all of the electrical equipment not needed to be at the tanks or in plain view of the workers and supervisors while operating the process, is separated from the tanks by masonry walls and is enclosed within strong wire cages. This is a safety measure.

Excess Hydrogen for Safety

An excess of hydrogen is fed and is burned constantly at the generator vents. This is another safety measure. It excludes air which, if it entered the generator, might cause an explosion. Care also must be taken that the flames be not extinguished as dangerous amounts of free hydrogen might then gather at the ceiling of the room.

Metallic sodium is liable to spontaneous combustion if exposed to the open air and must be kept covered accordingly.

Water entering the bath can cause the hot caustic to fly, which is dangerous with the caustic at 700 F. Water must be kept away from the metallic sodium, a fact that every engineer will recall from his high school chemistry experiments.

The metallic sodium is kept in steel drums close to the tanks. The process of feeding it is simple. The operator puts on a plastic safety mask and wears gloves. With his gloved left hand he picks up a brick of sodium, with tongs held in his right hand he removes a lid from a generator vent, then he puts the brick down through the vent and replaces the lid.

In actual operation of the process the men first examine the stock to make sure that it is dry and to determine the character of its scale. By simple inspection they can tell the minimum time which any type of scale must be exposed to the bath to loosen it.

The stock is mounted on a rack or other carrier. Care must be taken that individual surfaces are so separated or spaced that the caustic and the water in the quench can get at them all. With bars this calls for spacers so the bars are in tiers and for keeping the bars separated along the spacers. Spacers can be made of any stainless steel scrap, round shapes preferred. The only destruction of the spacers comes from the mild dilute acid exposures that complete the process, and this destruction is slow.

A carrier load is lowered slowly into the tank. The slowness is to avoid all splashing and also to minimize the cold shock to the bath. The rack or carrier rests on supports within the tank so the stock does not touch the tank bottom and there is free circulation of caustic about the stock.

After the necessary 10 to 12 min. of immersion the load is lifted clear of the surface of the liquid and is allowed to drain. The purpose of drainage is to avoid excessive drag out of the caustic. The sodium hydride becomes caustic soda when it absorbs oxygen and the amount of caustic thus formed at Carpenter is so exactly equal to the drag out that no new supplies of caustic are needed.

The load then is taken to the water quench bath and slowly lowered into the water. The reasons for not plunging it in rapidly are to prevent steam from being generated so rapidly that it will throw hot water into the descaling bath.

Little scale comes off in the caustic bath. Nearly all of it comes off in the water quench, and this simplifies the problem of keeping the equipment cleaned out.

The descaled metal is next taken to a 5 to 10% sulphuric acid bath. Sulphuric is chosen merely for its low cost; any acid would serve to neutralize any caustic which remained on the metal after the water quench. Some always does remain since the quench accumulates caustic from the successive lots of metal.

Acid also is necessary for stainless steel because the sodium hydride treatment leaves fine particles of pure iron on its surface and these particles would be rustable if not removed.

Costs of materials are difficult to estimate. The amounts used depend upon the square inches of surface exposed and not upon the tonnage processed.

As a rough estimate, from 6 to 12 lb. of metallic sodium are used for each ton of metal descaled, and the price of this sodium is about 15 to 15.5 cents per lb. If all of the hydrogen were combined with the sodium to form the hydride then about 7.8 cu. ft. of hydrogen would be consumed for each 1 lb. of sodium —in the operation of one unit in this plant 20 lb. of sodium and 270 cu. ft. of dissociated ammonia were used per hour.

Comparative Costs Not Known

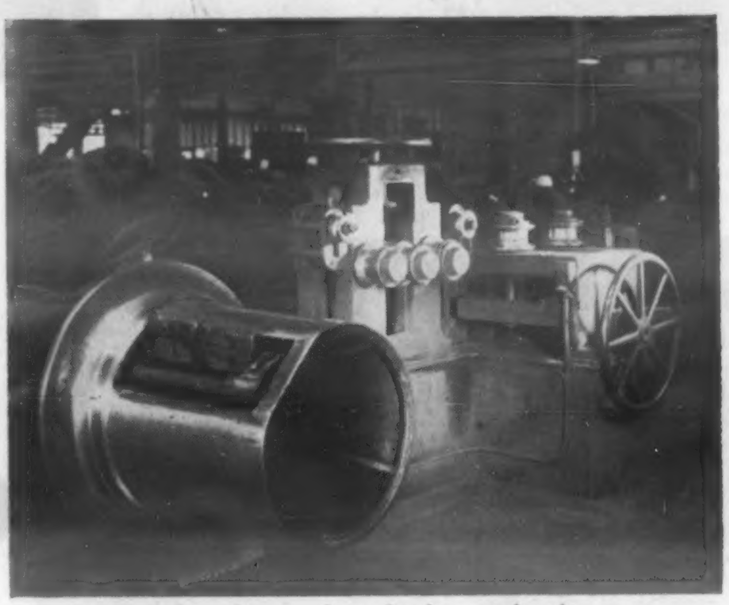
It is unfortunate that comparative costs between this process and conventional pickling on a peacetime production scale are unknown. The Carpenter Steel Co. put one sodium hydride unit into operation in 1943, another in 1945. Both were war years with production speeds more important than costs. The hydride process really has two kinds of costs. One is the steady operating cost to keep the units up to temperature and functioning when not in use. The other is the slightly higher cost when in use. Since the cost goes on so steadily the cost per ton of metal descaled will vary inversely to the tons of metal descaled with a cost curve which would almost be flat if all lots of steel had equal amounts of surface area per ton.

This is, then, a process to be studied carefully by any plant which has difficult descaling problems, or which is avoiding desirable heat treatments or the use of desired alloys because of the difficulties of descaling, or is now using such tumbling or pickling or other descaling methods as to result in pitted or abraded surfaces with consequent difficulties in polishing.

Equipment Capacities

Two sodium hydride descaling units are now in service at Carpenter Steel. One unit has a 200-kw. connected load, with both working dimensions of 8-ft. length, 4-ft., 6-in. width and 5-ft. salt depth. It has a heating capacity of 5,000 lb., gross, per hr. heated from room temperature to 700 F.

The second unit has a connected load of 500 kw. and is 25 ft., 8-in. long, 3-ft. wide and a salt depth of



Mechanical breaking of scale formerly done on machines like this no longer is needed.

4 ft. Its heating capacity is 12,000 lb., gross, per hr. heated from room temperature to 700 F.

Both units are operated from a power supply of 2400-v., 3-phase, 60-cycle. Transformers convert the 2400 v. directly to the low voltage range of 8 to 14 v. and these low voltages are impressed directly on the immersed electrodes in the baths. Heating is through the immersed electrode principle which operates in a manner whereby pairs of electrodes—closely spaced —generate the heat directly in the bath by virtue of the resistance of the column of liquid salt lying between the faces of each pair of electrodes. Electromagnetic forces created in the electrodes produces a stirring action.

Increasing knowledge of how to use glass and more know-how of its fabrication have led to its increased application alone and with metals.

An important industrial application of high strength-corrosion resistant glass; the impeller and casing of this centrifugal pump and made of heat and shock resisting borosilicate glass. These pumps are used in handling corrosive acids and other chemicals. (Courtesy: Nash Engineering Co.)

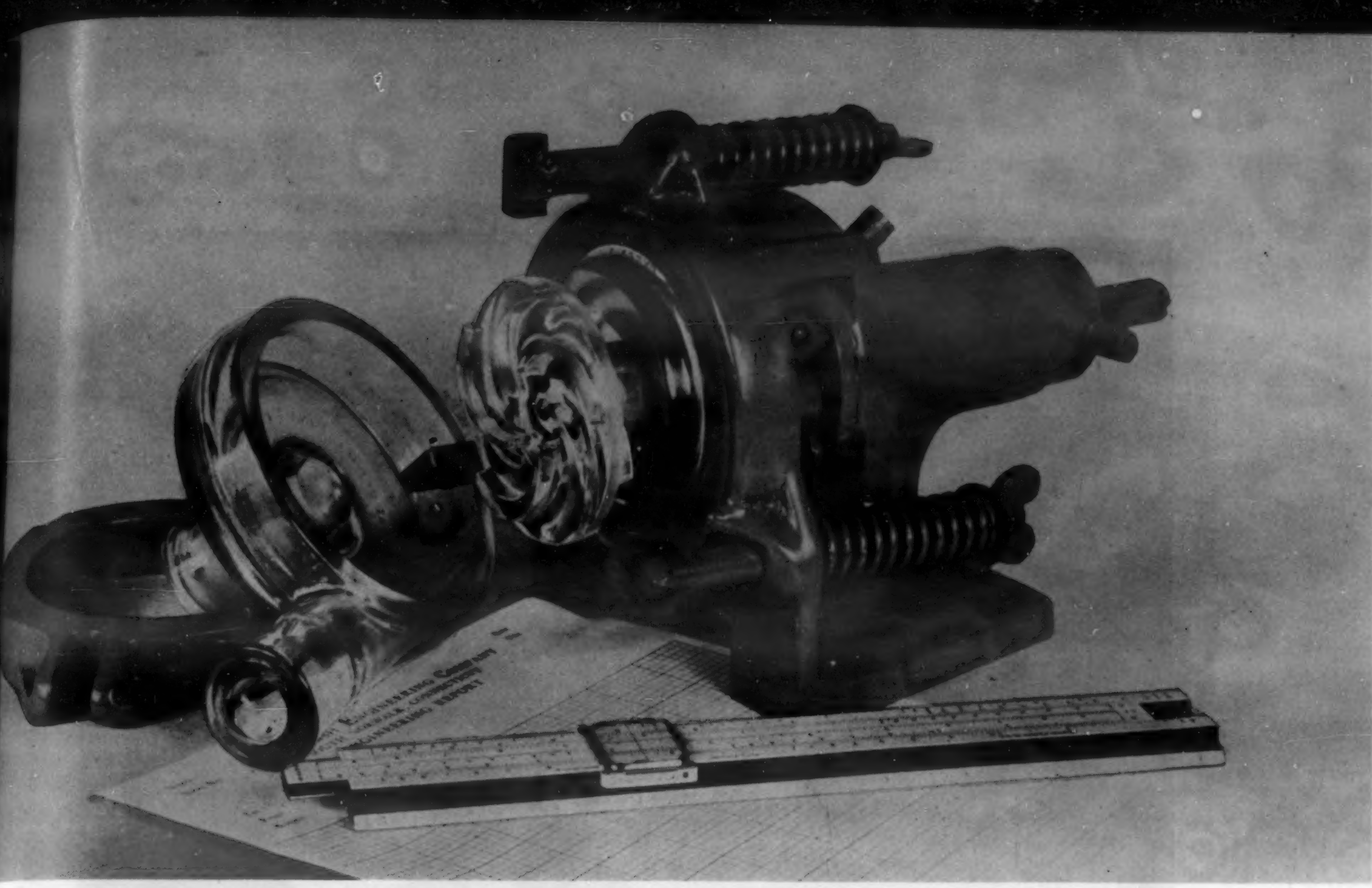
Some Uses of Glass as an Engineering Material

by CHARLES F. LINDSAY, PH.D., *Consulting Metallurgist, United States Testing Co., Inc.*

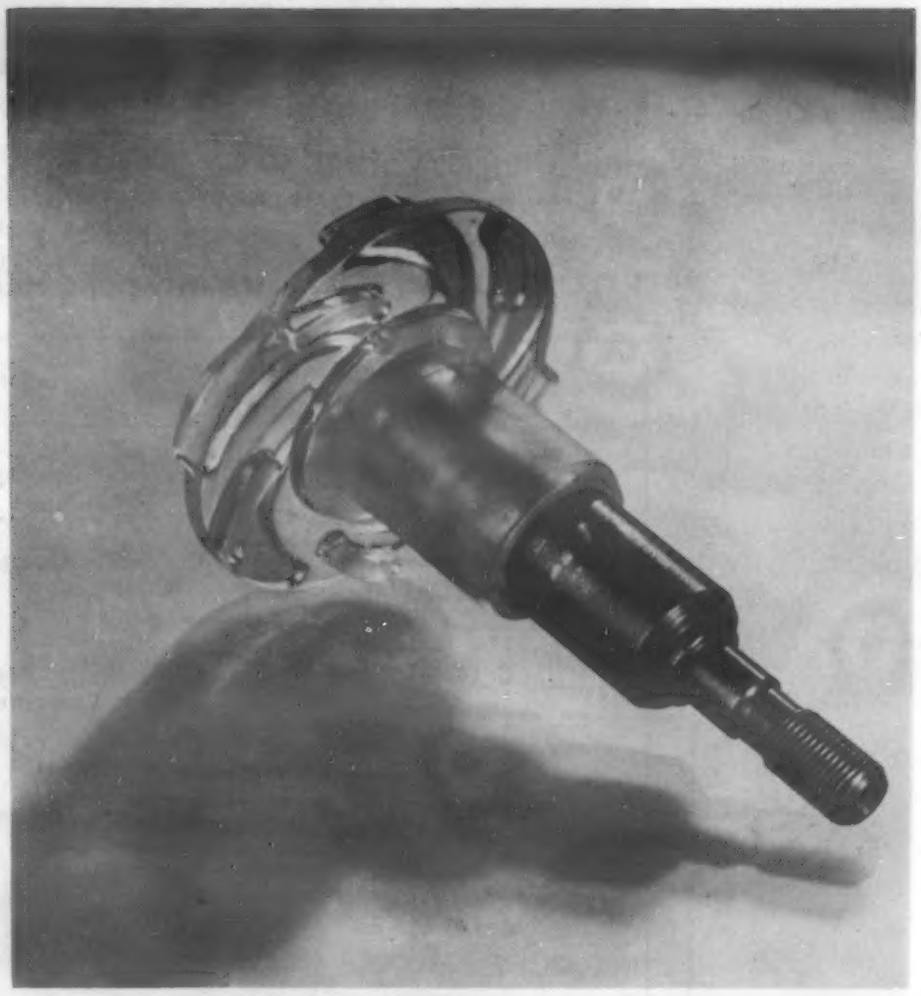
DURING THE PAST FEW YEARS glass has assumed new and growing importance as an engineering material. There have been a number of special purpose types of glass developed, among these are glasses that are highly resistant to mechanical or to thermal shock, or that possess special expansion properties. It is not the purpose of this article to describe the methods of manufacture or detailed treatments, but to point out some of these special types of glass and their properties that make them of interest to materials engineers.

One of the most common technical applications of glass is in the making of envelopes, bulbs or containers for such important items as incandescent lamp bulbs, X-ray tubes and vacuum tubes (rectifiers, amplifiers, power tubes, etc.). The properties that make glass valuable for such usages include its resistance to mechanical shock and to the high operating temperatures of these devices, plus high electrical insulating properties, transparency, and its ability to be worked, shaped and blown with reasonable ease. The glasses usually chosen for envelopes of electronic tubes are the class known as borosilicate glasses.

Borosilicates are so called hard glasses and have relatively low coefficients of thermal expansion. Since all these devices listed above (lamp bulbs, X-ray and vacuum tubes) require power leads for introducting the electricity into the tube, they involve the sealing of metallic conductors into the glass in a glass-to-



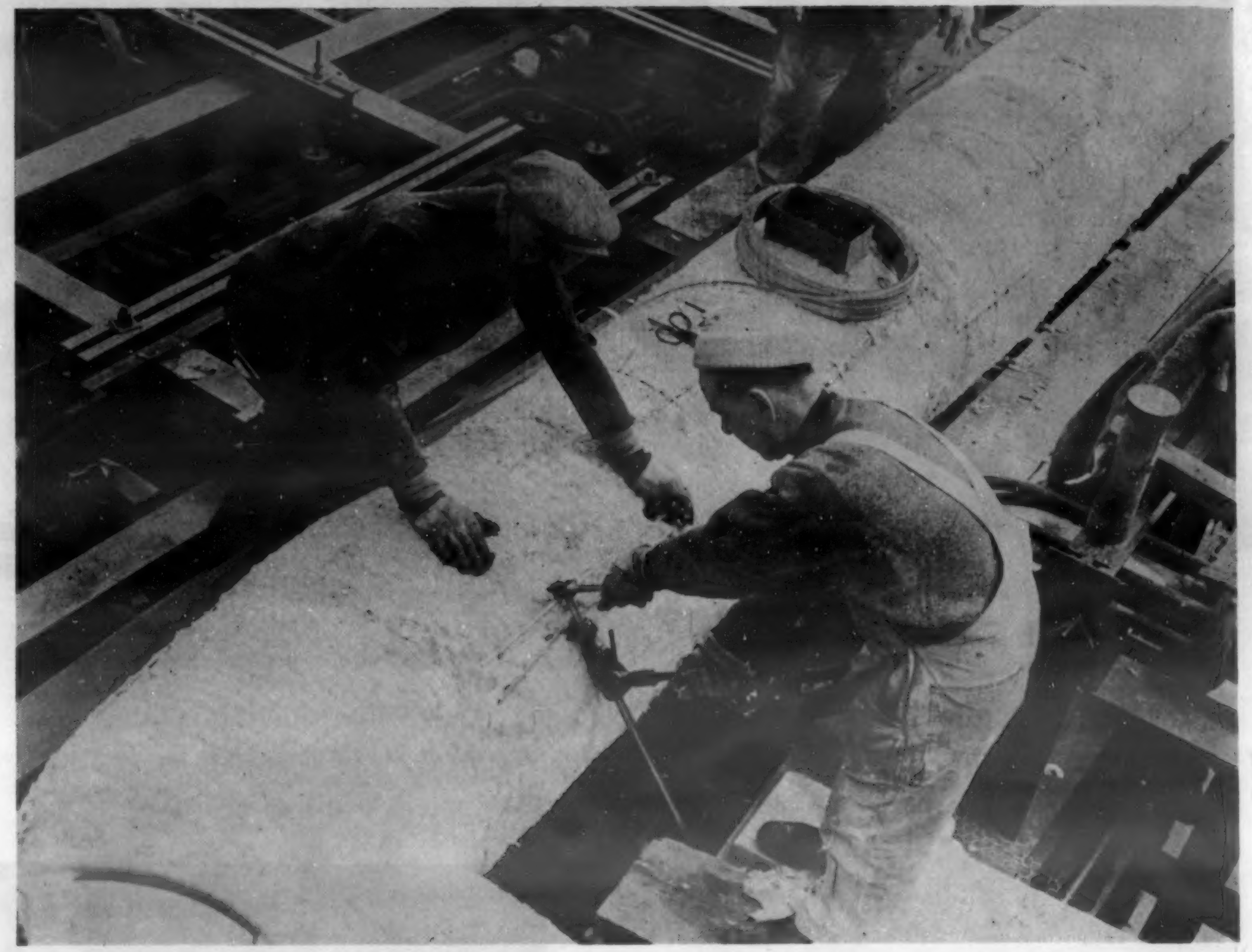
Partially assembled centrifugal pump showing glass impeller in position. (Courtesy: Nash Engineering Co.)



The glass impeller of pump shown above. Note that extension of impeller shaft is steel. (Courtesy: Corning Glass Works.)

metal seal. Some glass-to-glass seals are also used. The making of satisfactory vacuum-proof and mechanically sturdy seals involves solving such problems as finding a glass that will have nearly the same coefficient of thermal expansion as the metallic leads and at the same time have a sufficiently high softening temperature so that it will stand up under the normal operating temperatures found in this type of apparatus. This brings us to a consideration of the stresses set up in seals and the safe limits for such stresses. A detailed study of the stresses and strains in glass-to-glass and glass-to-metal seals has determined that the maximum allowable stresses are:

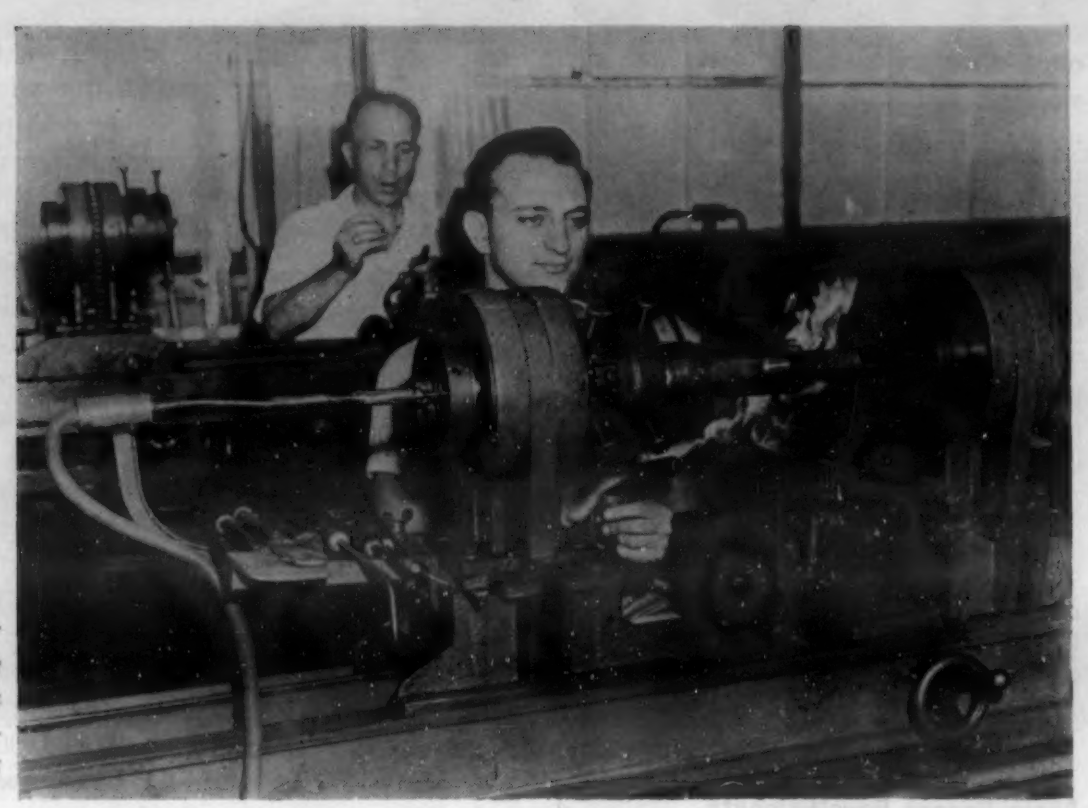
glass-to-glass seals 2133.5 psi.
glass-to-metal seals 1280.1 psi.



Using glass fibre blanket-type insulation on process steam lines. (Courtesy: Owens-Corning Fiberglas Corp.)

TABLE 1. ASTM SPECIFICATIONS RELATING TO GLASS, ITS MANUFACTURE AND TESTING

Spec. No.	Title	Remarks
C 146-43	Chemical Analysis of Glass Sand	Gives methods for the analyses of sands used in making glass
C 169-43	Chemical Analysis of Soda-lime Glass	Soda-lime glass is used for many commercial products such as window and plate glass
C 147-43	Hydrostatic Pressure Test on Glass Containers	Procedure for determining breaking strength of narrow-mouth glass containers when subjected to a uniform internal hydrostatic pressure
C 148-43	Polariscopic Examination of Glass Containers	Test method for checking the efficiency of the annealing (stress relieving) of glassware
C 149-43	Thermal Shock Test on Glass Containers	Method for determining the thermal shock resistance of glass products
C 158-43	Flexure Testing of Glass	Determination of modulus of rupture of glass (the stress at which a standard test specimen breaks in a flexure test)



Sealing the rotating copper anode into a glass X-ray tube involves making precision glass-to-glass joints. (Courtesy: North American Philips Co., Inc.)

These stresses were calculated and then checked photo-elastically with carefully annealed test seals. Such stresses as these are due largely to the differences in the coefficients of thermal expansion of the materials used in the seal. It is only by selecting the proper lead material and the appropriate type of glass (so that the difference in coefficient of expansion is as small as possible) that such marvels of modern manufacture as 2,000,000-v. X-ray tubes are possible.

Another important property of the type of glass used for the envelopes of vacuum tubes is its ability to withstand the high baking temperatures (near 850 F) necessary to drive off the adsorbed and dissolved materials (such as water vapor and carbon dioxide). The glass envelope must be freed of these volatile materials before it can be sealed, otherwise it would not "hold" a proper vacuum.

Increasing Strength of Glass

Most ruptures in glass occur while the material is under tension. For this reason many glass articles must be so designed that any tensile stresses that might develop will be as uniformly distributed throughout the glass as possible. To accomplish this, all surface scratches and re-entrant angles are generally avoided and the surface of the glass is placed in compression by controlled annealing. The result of this is to create a tough glass that, in many cases, can have one surface heated and then have cold water dropped on the other without cracking.

The standard methods for testing and controlling glasses are given in the pertinent ASTM specifications which are listed in Table 1.

Artificial Quartz

H. P. Hood and M. E. Norwood of the Corning Glass Works made an important discovery in finding that borosilicate glass could be so heat treated, following the usual forming and cooling operations, that the material would separate into two distinct phases. One of these phases is so high in boric and alkali oxides that it can be readily dissolved in normal acids at temperatures near the boiling point of water. Following this acid treatment, which leaves

TABLE 2. COMPARISON OF BOROSILICATE GLASS SILICA GLASS AND VITREOUS SILICA

Property	Borosilicate Glass	96% Silica Glass	Vitreous Silica (fused quartz)
Softening Temp.	1500 F	2750 F	3000 F
Annealing Temp.	1025 F	1630 F	2085 F
Strain Point	950 F	1450 F	1960 F
Coef. of Expansion (per deg F)	0.0000018	0.00000044	0.000000031
Density (lb/in³)	0.0803	0.0785	0.0792

only the very-high-silica content shell, the glass is washed to remove all traces of the acid and then dehydrated at a high temperature. The glass shrinks in volume about 35% and the resulting vessel is transparent, non-porous and composed of about 96% silica. By this method, it is possible to create artificially a glass possessing properties very close to those of vitreous silica—fused quartz—(very low coefficient of thermal expansion plus a high melting point) at a fairly low cost. A comparison of some of the properties of this synthetic quartz or vitreous silica, 96% silica glass and a common grade of chemical resistant borosilicate glass is given in Table 2.

This silica glass is an important development. One of its outstanding uses is for the vacuum bottles used in melting and casting metals under a vacuum. When used for this purpose, the vacuum containers have a length of life triple that of the formerly used material and a cost of about one third.

Some Recent Developments

A new development in glass products is an insulating medium consisting of a multitude of tiny glass tubes held together with a binder and molded in bricks and other convenient shapes. This insulating material is very light (weighing about 10½ lb. per cubic foot) and is capable of withstanding relatively high temperatures. The low conductivity of these glass fibre blocks (approximately 0.4 Btu/hr/ft^{2}deg F/ in. at 50 F and 0.55 Btu/hr/ft^{2}deg F/ in. and their physical stability make them useful for insertion between firebrick walls to improve the overall insulation properties of the structure. Of course the volume change with moisture absorption is zero, the blocks being essentially glass.

Other structural uses of glasses are becoming common place. The Lincoln Tunnel (from New York to New Jersey under the Hudson River) has its concrete walls and roof lined with a continuous surface that is formed by anchoring sheets of glass directly to the concrete. Glass tile is a new interior building material. These tiles have good insulation properties because of a partial vacuum in the center. They are formed of two parts that have been cemented together around the edges while hot; the vacuum is produced when the interior cools. Such tiles are of course, transparent or translucent and make useful material for interior partitions because of their light transmitting ability.

Until recently it was not economically possible to make fine glass fibres. Now, glass filaments or fibres as small as 0.0002 to 0.0003-in. in diameter are feasible. These fibres can be made in two forms commonly known as staple fibre and continuous fibre; the difference between these is analogous to the difference between cotton and wool on one hand and silk and rayon on the other. By processes similar to those used in the conventional textile mills, glass fibres can be spun and woven into such useful products as cloth, tape, yarn, etc. As bats and rolls, the glass fibre is used for insulating ovens and refrigerators, and in air filters. Fireproof and vermin and fungus proof glass cloth and woven glass fabric impregnated with plastic materials are some of the newer items finding increasing industrial usage.

QUICK REFERENCE TO PREVIOUS ARTICLES ON GLASS AS AN ENGINEERING MATERIAL

Title of Article	Reference	Scope
Glass Gages Engineering File Fact No. 52	Metals and Alloys, Vol. 20, No. 1 (July, 1944), p 109	Types of gages made of glass, their characteristics and glass gage finishing techniques
Glass Tanks for Pickling and Plating by C. L. West	Metals and Alloys, Vol. 21, No. 2 (Feb., 1945), pp 413-416	Glass as a corrosion resistant tank lining, and tanks made of glass
Glass as an Industrial Material Engineering File Fact No. 81	Metals and Alloys, Vol. 21, No. 5 (May, 1945), pp 1359 & 1361	Commercial forms of glass, their preparation, types and uses
Glass-Types and Compositions Engineering File Fact No. 84	Metals and Alloys, Vol. 21, No. 6 (June, 1945), p 1673	General properties, typical compositions and types of glass
Some Materials and Methods for X-Ray and Power Tube Manufacture, by C. F. Lindsay	Materials & Methods, Vol. 23, No. 2 (Feb., 1946), p 406 ff	The materials and processes used in making X-ray and electronic power tubes
Properties and Fabrication of Glass Reinforced-Plastics, by James Slayter and H. W. Collins	Materials & Methods, Vol. 23, No. 3 (Mar., 1946), p 720 ff	Properties and uses of woven glass-resin materials

For lining this 63-ft. long isomerization reactor vessel, Hastelloy A and B nickel-base alloy were used. The equipment is used chiefly to produce 100-octane gasoline.

Pressure Vessels Made With Welded Nickel Alloy Linings

by T. H. MENAUGH, *Graver Tank & Mfg. Co., Inc.*

A TOUGH SERVICE for any material or method is equipment that must stand corrosive influences of hydrochloric acid, temperatures up to the boiling point and high pressures such as isomerization reactor vessels used in the petroleum industry. These are "must" equipment used in producing high test gasoline, styrene and kindred products. Through such vessels we were able to produce annually during the war 3,500,000 gal. of 100 octane gasoline.

In the crucial days of 1943 a sudden failure of equipment at an Oklahoma refinery caused the sending of an emergency call for manufacture of more of these vessels. One company to receive a hurry-up contract was the Graver Tank & Mfg. Co., Inc., East Chicago, Ind., whose assignment was manufacture of a vessel 63-ft. long, 7-ft. in dia. with a 1⅝-in. steel plate for the shell, cone bottom and dished top, all lined with a Hastelloy nickel base alloy.

This article is concerned with materials and methods used in lining the tanks. Various grades of Hastelloy were tried out for linings and experience taught which of several techniques were most suited to applying the welds. Original specifications called for Hastelloy A (nickel 57.00; iron 20.00; manganese 2.00; silicon 1.00; molybdenum 20.00; carbon 0.15%)

Specialized welding methods are used to line tanks with special alloys that can withstand high temperatures and pressures as well as corrosive acids.

Here show plainly the 6-in. strips of lining. At the far end is the dished and shaped top. Two miles of welds appear in the lining.

because of its resistance to corrosion by hydrochloric acid. A newer variation, Hastelloy B (same silicon and carbon as A—but nickel 62.00; iron 6.00; manganese 1.00; molybdenum 30.00%) was later substituted as it is superior at all temperature ranges up to and including the boiling point.

Hastelloy A is for relatively low temperature applications, being used to handle hydrochloric acid up to 160 F. Alloy B serves up to the boiling point.

All of the Hastelloy alloys can be welded readily and shops experienced in welding Monel, stainless steel, nickel and other metals usually can adapt their practices to welding Hastelloy alloys. The electric arc process is commonly employed. Where oxy-acetylene is used, carbon pick-up and overheating are to be especially avoided. Carbon pick-up can be minimized by using a neutral flame, guarding against excess of acetylene.

Welding Procedure

At the Graver plant, where the procedure is typical, the steel shells are given an X-ray inspection and then pass through one of the country's largest stress relieving furnaces, then are ready for the application of welding. The alloy is received by Graver in sheets of standard dimension, then sheared to 6-in. strips. No. 12 gage is used for the lower shell and cone bottom, with No. 14 gage for the remainder.

Welding the 6-in. strips by the electric arc process to the interior surface is an entirely manual operation and requires over 2 miles of weld. Haynes Stellite

Co. furnishes both lining material and welding electrodes, the latter being of the same material as the sheet lining except for alloy A, for which alloy B electrodes are used.

Graver leaves a space of 7/16-in. between each strip. At each seam a fillet is run along each meeting of shell and liner, leaving an exposed area ⅛-in. wide at each joint. This exposed area is filled by weaving a bead over it and the two adjacent fillets. Thus each seam requires three separate welds. One might say that the shell was first welded to the liner and then two sheets of Hastelloy are welded to each other. With but one weld it would be impossible to inspect visually the junction of shell and liner. A ⅛-in. rod is used on the first two fillets and a 5/32-in. electrode for the bead over them. As a Graver official expresses it, "the success of the operation is largely credited to a close attention to the preparation of the material and a conditioning of the welding rods".

When the lining is completed, the vessel is subjected to a hydrostatic test to reveal imperfections in the welded seams to the inner shell. To determine leaks in the interior seams the column is returned to the furnace and heated to 400 F. Any moisture remaining between the Hastelloy sheets and the shell plate is forced to the inner surface and upon cooling leaves a slight deposit of scale, which is marked for final welding.

Graver constructed three reactor columns by this method and received a letter of commendation from the Petroleum Administrator for War.

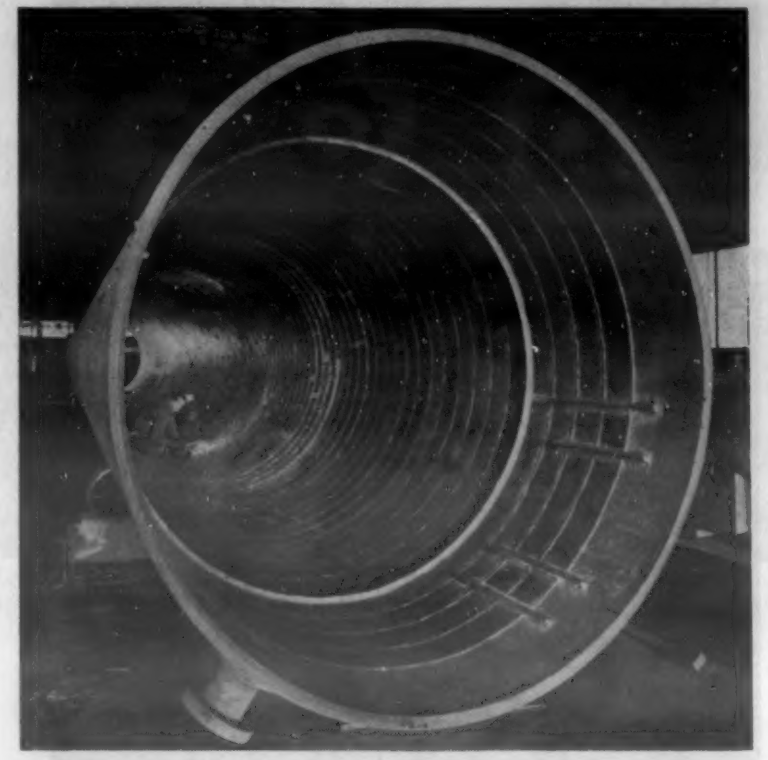
In commenting on the Graver method, officials of the Haynes Stellite Co. give some supplemental information derived from the experiences at the A. O. Smith Co., Milwaukee, Western Pipe & Steel Co., San Francisco, and other users of the process.

Variations Developed

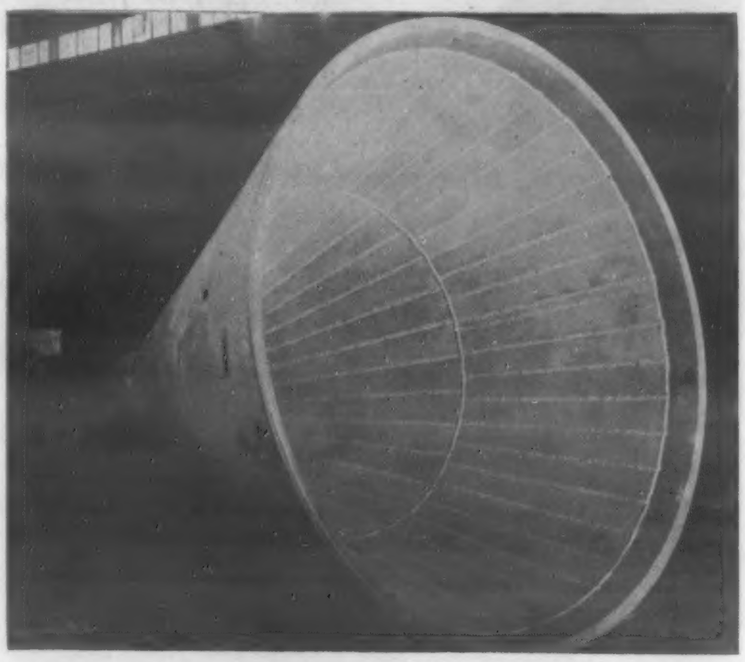
The method so far described is applicable only if the vessels are rotated when they are lined so that all welds are made in the downhand position. To take care of vessels already installed and in their normal operating position another process was developed—the installation of 6-in. Hastelloy strips by the lap weld method. Here the strips are installed circumferentially. Alternate circumferential bands, 6-in. wide, with 5½-in. space between, are welded first. The ends of each are lapped over each other. Strips then are placed over the 5½-in. wide areas of exposed shell and lap welded to the bands already in place.

One end of each strip is welded to the shell and the other end is lapped and welded over the adjacent strip. Upon completion of welding, all strips are individually tested for tightness. Turn buckles hold the strips tight against the shell since tack welds usually cause porosity if welds are made over them. The lap welded strips are welded with 3/32-in. or ⅛-in. Hastelloy B electrodes.

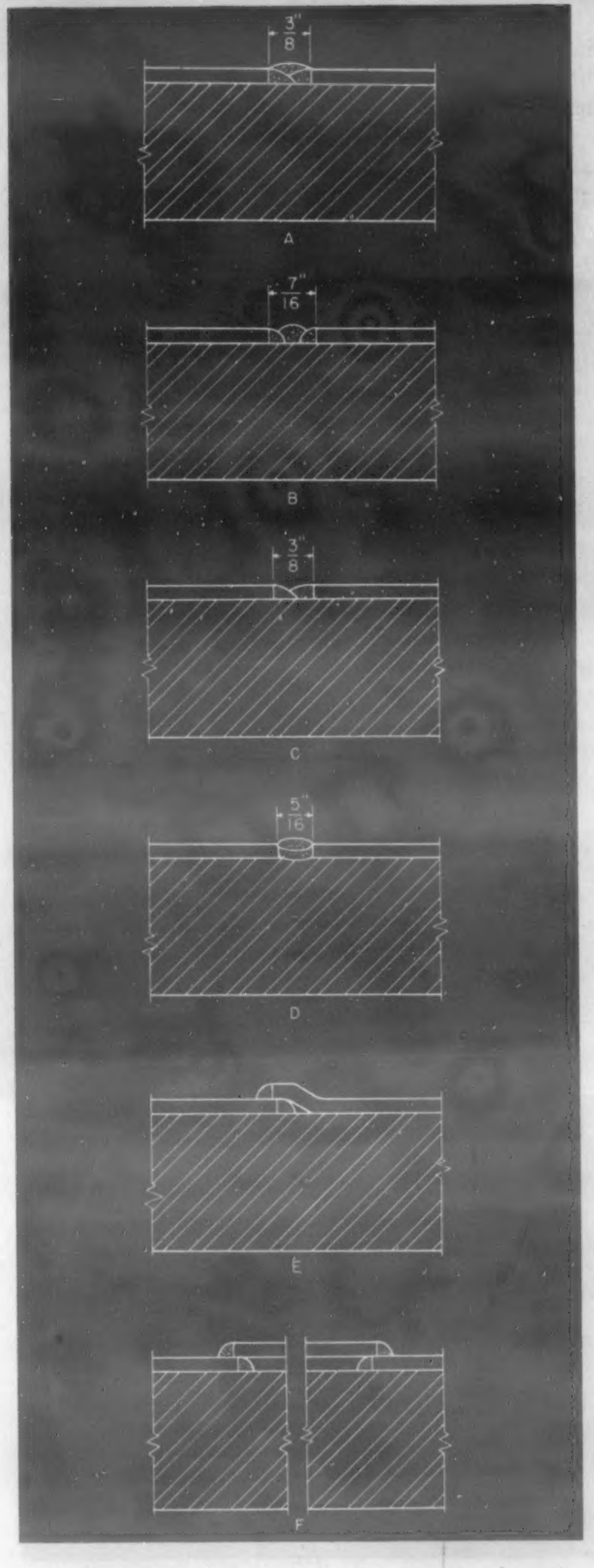
Variation of the above is the so-called "shingle" method, used considerably for the repair of old linings. It was employed after laboratory and field tests revealed that cold-worked Hastelloy B is not susceptible to corrosion. It consists of off-setting one long and one short end of each strip and lapping the off-set edge over the lower edge of the upped adja-



All welding in the application of the liner is manual, the electrode usually being of the same material as the lining strips.



For the cone-shaped bottom of the vessel, 1⅜-in. steel plate was used. No. 12 gage Hastelloy was used for lining the cone and lower shell plates and No. 14 gage for the top and upper portions.



Various methods have been tried in joining the strips —butt, lap and modifications of the latter. The three best methods are those shown in A, E and F. Corrosion is apt to set in at the bead boundaries, or edges, in methods shown in B, C and D.

cent strip. Each strip is welded and tested separately. Six-inch strips are used.

The conclusion of Haynes Stellite engineers is that No. 12 gage Hastelloy B strip lining should be used for all repairs and new installations, applied by either butt or shingle welding—the latter for installation of the lining in place. It is adapted for welding in vertical or overhead positions better than the butt method. In the latter, precautions should be taken that all welds are made in three passes and the cover pass extends the full width of the spacing between adjacent strips, completely covering the fillet beads below. Otherwise corrosion is apt to set in at bead boundaries.

Rules for Alloy Welding

Haynes engineers have laid down the following points for successful Hastelloy B lining of vessels.

1. Steel shells should be thoroughly cleaned, preferably by sand blasting.

2. Hastelloy B strips should be kept very tightly against the shell, not only to promote ease of welding, but also to dissipate more rapidly the heat from welding.

3. Welding should be done on cold strips and no preheating should be allowed as the alloy is hot-short at elevated temperatures.

4. Welding heat should be kept as low as possible and a short arc should be used. Normal current is 90-amp. at 25 v. with 3/32-in. electrodes and 120-amp. at 27 v. with ⅛-in. electrodes.

5. To further minimize the effect of heat in butt welding applications, the electrode must be directed almost entirely onto the steel shell and only the edge of the arc should burn into the Hastelloy strip.

6. Puddling at the weld to remove porosity or slag should be avoided. If necessary, remove the porous area and reweld.

7. Stringer bead welding should be used whenever possible.

8. Inasmuch as Hastelloy B electrode coatings are hygroscopic and moisture in the coating results in porosity in the deposit, all electrodes should be heated at 250 to 300 F for a few minutes before welding. If this is not practical, burning about ½ in. of the new electrodes or shorting the electrodes on the plate for a few seconds before welding will heat the coating and dry it.

9. Every precaution should be taken to avoid locked-up stresses in the lining. This involves sequence of welding and design and layout of the lining.

10. All welds should be tested for leaks with air pressure of 15 to 30 psi. and swabbing the strips and welds with soap suds. A more sensitive test is to introduce hydrogen chloride gas, under 5 to 10 psi. pressure, between the liner and the shell. The inside of the vessel is then swabbed with ammonia which produces a white cloud at the point of leakage.

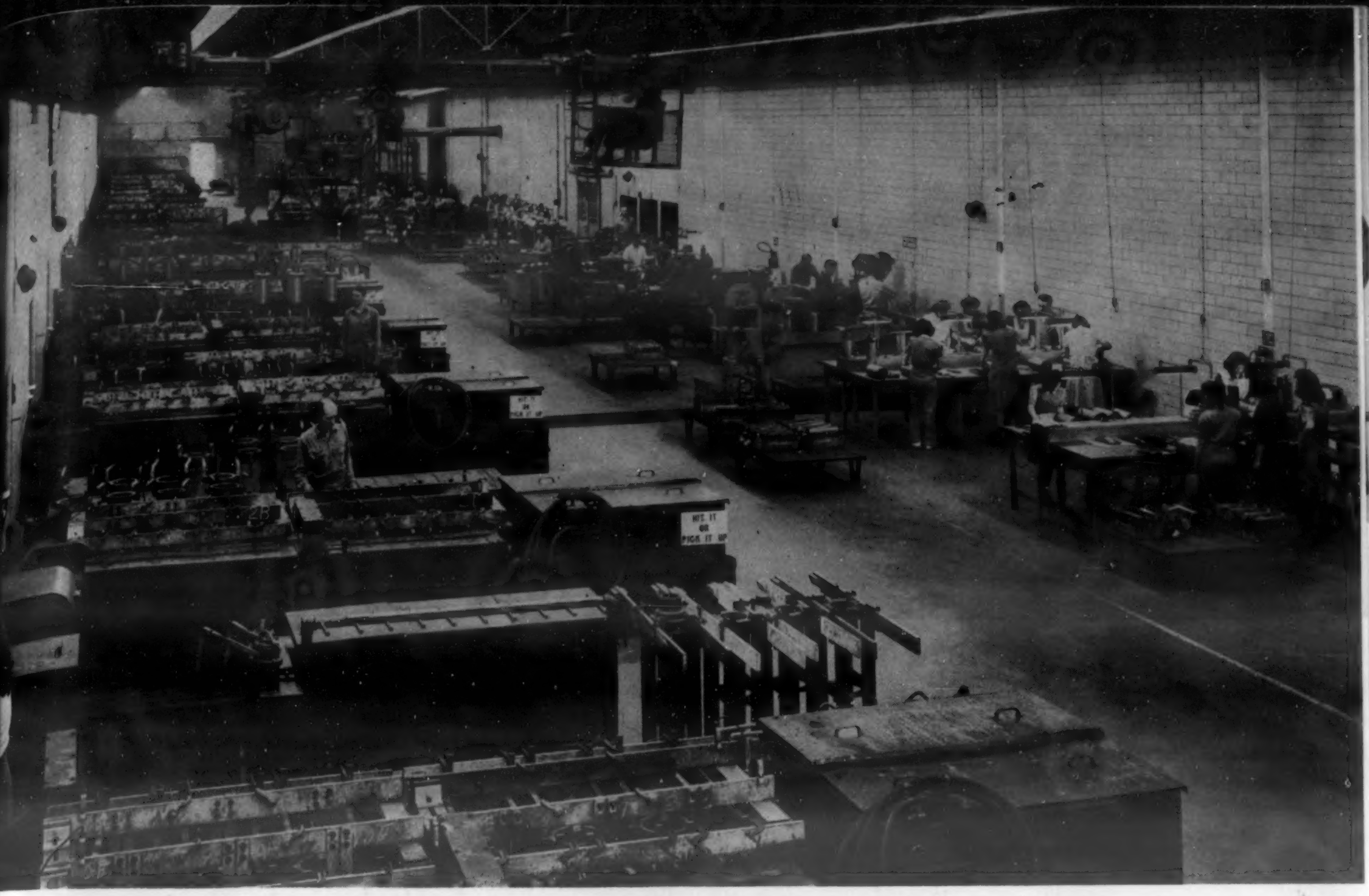


Fig. 1—All plating tanks and operations relating to plating of the rings are kept separate from the generators.

Porous Chromium Plating Adds to Piston Ring Life

by TRACY C. JARRETT and ROBERT D. GUERKE, *Koppers Co., American Hammered Piston Ring Div.*

FROM OUT OF THE CLOUDS of war there have come many outstanding developments; one of them is the porous chromium plated piston ring. In most airplanes the only parts of the entire plane that are still cast iron are piston rings and these, in turn, operate in the toughest spots in an engine.

This, however, is not so in the case of trucks, busses or automotive engines as there are a great many parts that are advantageously made of cast iron. The piston ring still does, however, operate in one of the toughest spots in the engine, that is, the combustion chamber. In a great many cases compression rings and particularly the top rings operate with minimum lubrication. Should this condition be allowed to continue long enough considerable cylinder and ring wear takes place. When this condition is severe, the rings feather or scuff and the oil consumption increases beyond the normal for good engine

Exhaustive tests show plated rings give about five times the ring life and 50 to 80% less cylinder wear than similar types of unplated rings.

Fig. 2—In preparing arbors of piston rings for plating, gaps at the joints of the rings are filled with lead. Arbors hold approximately 100 rings.

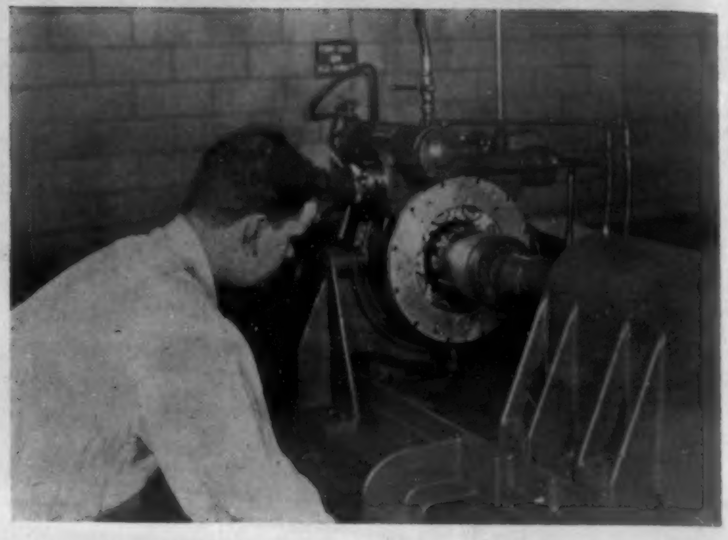


Fig. 3—Rings on arbors are honed to a finish of 10 R.M.S. or less to remove all surface defects.

performance. When this undue wear of rings and cylinders takes place, the engine itself cannot operate at top efficiency. The wearing of the rings and cylinder, under extreme dusty conditions, is most serious and presents a major problem today. The ideal piston ring is one that will resist wear, will not feather or scuff, and at the same time will not cause cylinder wear.

A porous chromium plating process, originated by H. van der Horst, has made it possible to produce porous chromium surfaces which do resist wear. The porous chromium plate applied to piston rings is entirely different from the usual bright plate used on bumpers, door knobs, and other parts. It is applied to the cylinder contacting surface of the piston ring and permits the ring to seat itself quickly, without wearing out. The porosity has the ability to carry oil and to condition the cylinder during this seating in period, the final result being two perfectly mated surfaces. This porous chromium surface, when applied to piston rings, increases the life of the rings approximately five times and reduces the cylinder wear from 50 to 80% of that obtained with unplated rings. These two important advantages have made it possible to increase the time between overhauls and maintain high operating efficiency.

TABLE 1.

WEAR OF CHROMIUM-MOLYBDENUM CYLINDERS RUN WITH POROUS CHROMIUM PLATED RINGS

(Operated under abnormal dust conditions)

Engine No.	Appoximate Horse Power	Number Hours Operating Time	Cylinder Wear Measured on Diameter, In.
A	2,000	106	0.002
B	2,000	310	0.003
C	2,000	460	0.002
D	2,000	590	0.003

TABLE 2.

WEAR OF CHROMIUM-MOLYBDENUM CYLINDERS RUN WITH PLAIN CAST IRON RINGS

(Operated under abnormal dust conditions)

Engine No.	Appoximate Horse Power	Number Hours Operating Time	Cylinder Wear Measured on Diameter, In.
E	2,000	70	0.006
F	2,000	107	0.012
G	2,000	224	0.010
H	2,000	301	0.016

TABLE 3.

WEAR OF POROUS CHROMIUM PLATED RINGS OPERATING AGAINST CHROMIUM-MOLYBDENUM BARRELS

Engine No.	Approximate Horse Power	Knoop Chromium Plate Hardness[a]	Number Hours Operating Time	Remaining Chromium[b] Thickness, In.	Average Ring Wear
J	2,000	823	68	0.004	0.001
K	2,000	885	108	0.003	0.002
L	2,000	859	315	0.0028	0.0022
M	2,000	807	453	0.0018	0.0032

[a]The hardness of chromium plate was tested on the Tukon tester using a 100-g load and after engine operation. Original hardness before test was 850 to 950.

[b]Average 0.005-in. chromium thickness on the radius originally.

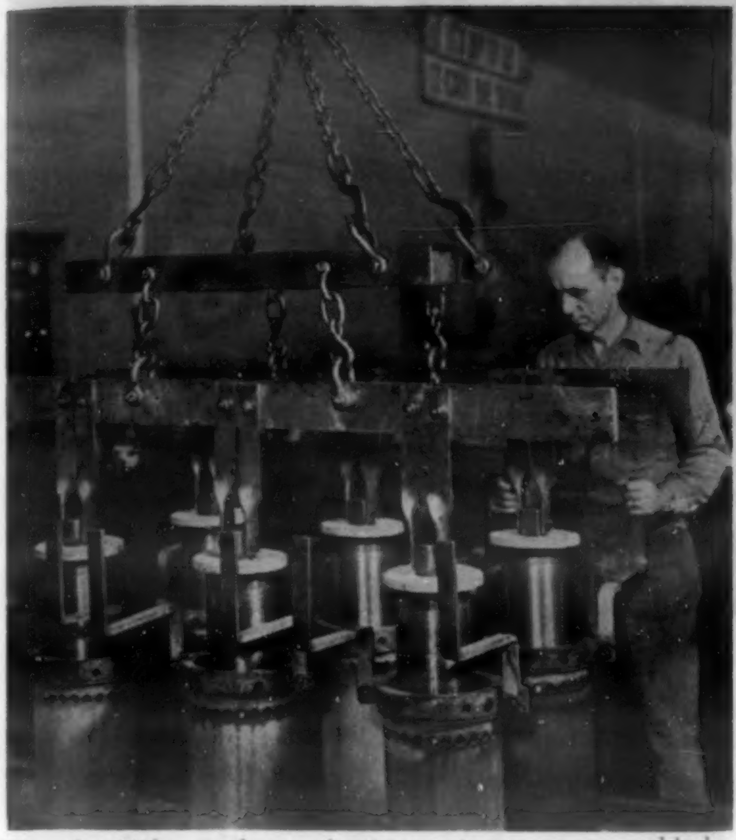


Fig. 4—When arbors of piston rings are assembled in anodes, top spacers and anode pins keep the arbors in perfect alignment and parallel to anode walls.

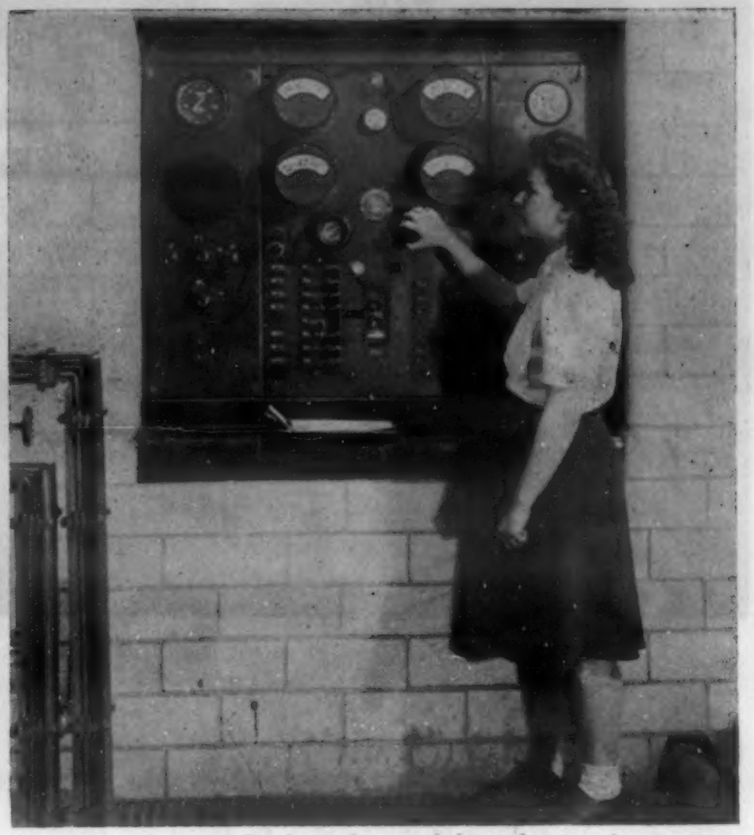


Fig. 5—A central control panel board permits operators to maintain accurate control over tank during entire plating cycle.

In an aircraft, bus, truck or automotive engine, it should be pointed out that only the top ring of each piston is chromium plated and the remaining compression and oil rings are plain gray iron.

Field test data were obtained from different sections of the country and from different types of engines. The following tables show the barrel wear of different types of engines, some using plain cast iron rings in the top groove, and others with porous chromium plated rings in the top groove; the approximate amount of wear on the chromium plated ring; and the hardness of the remaining chromium plate; typical cylinder wear rates for bus and truck engines using cast iron porous chromium rings and typical ring wear rates using cast iron and porous chrome rings in bus and truck engines.

A typical specification for a chromium plated aircraft ring calls for a plate thickness of 0.004 to 0.006 in. on the cylinder contacting surface, a depth of porosity of 0.0007 to 0.0015 in., hardness of the plate of not less than 775 Knoop hardness numbers, and a microinch finish on the plated surface of 30 to 90 R.M.S. with a uniform appearance.

In the process of plating the rings, great care is exercised at all times first in preparing the work for plating and second in the maintenance of the plating solutions. Analyses of the solutions are made daily to determine the total chromic acid content, the trivalent, the amount of iron present, hexvalent content, and sulphate ratio.

The plating room, shown in Fig. 1, uses filtered air to insure a complete absence from dust, and the room is kept under pressure to keep outside air which may be laden with dust from entering. The air is changed every two minutes to keep any possible fumes from coming in contact with the workers,

TABLE 4.
WEAR OF NITRIDED CYLINDERS RUN WITH POROUS CHROMIUM PLATED RINGS

Engine No.	Approximate Horse Power	Number Hours Operating Time	Cylinder Wear
O[c]	1,200	28	0.001
P[d]	1,200	593	0.000

[c]Operated under abnormal dust conditions.
[d]Operated under normal dust conditions.

TABLE 5.
WEAR OF NITRIDED CYLINDERS RUN WITH PLAIN CAST IRON RINGS
(Operated under abnormal dust conditions)

Engine No.	Approximate Horse Power	Number Hours Operating Time	Cylinder Wear
R	1,200	195	0.008
S	1,200	559	0.010

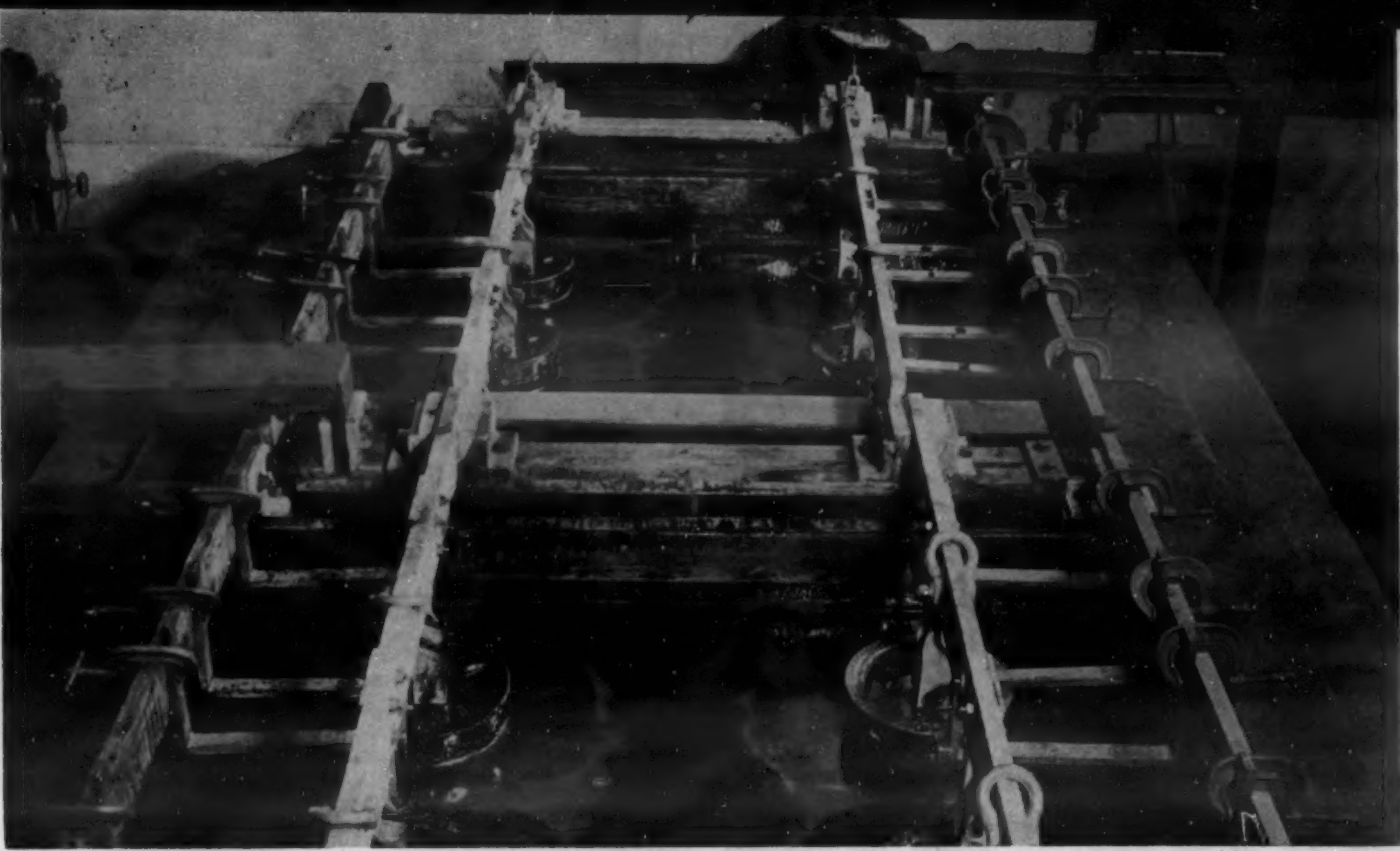


Fig. 6—The heavy flow of gas around each arbor indicates that plating is proceeding properly.

although the chromium plating tanks have their own individual exhaust systems. All of the tanks are set in a deep pit, which is well drained, and any acid or water coming from cleaning the anodes or arbors drains into the pit. This helps to preserve the dust-proof floor from the attack of acids. Tile walls aid in keeping the room clean and bright as any acid that might come in contact with the walls may be easily removed.

Generators are in a separate air filtered room. The filtering of the air increases the life of the generators considerably. The power for each tank is supplied by two 4,000 amp., 12 v. generators, with common excitation driven by one 150 hp. motor. By having two generators on one set, it is possible to operate the two halves of a tank with two different sizes or types of rings.

Before plating, piston rings are loaded on arbors which contain about 100 rings and, in order to obtain a uniform plate, continuous contact must be maintained and is accomplished by filling the gaps at the ring joints with lead (Fig. 2). This assures a uniform plate around the ring and up to the end of the joint. The arbors of rings are honed before plating to provide smooth surfaces for plating—the better the surface the better the bond between the ring and the chromium plate (Fig. 3).

TABLE 6.

WEAR OF POROUS CHROMIUM PLATED RINGS OPERATING AGAINST NITRIDED BARRELS

Engine No.	Approximate Horse Power	Knoop Chromium Plate Hardness*	Number Hours Operating Time	Remaining Chromium† Thickness, In.	Average Ring Wear
T	1,200	879	150	0.0039	0.0011
U	1,200	912	745	0.0040	0.001

*The hardness of chromium plate was tested on the Tukon tester using a 100-g load and after engine operation. Original hardness before test was 850 to 950.

†Average 0.005 in. chromium thickness on the radius originally.

TABLE 7.

TYPICAL CYLINDER WEAR RATES FOR BUS AND TRUCK ENGINES USING CAST IRON POROUS CHROME RINGS

Engine Make	Model	Bore (in.)	Cylinder Wear per 1,000 Miles: Cast Iron Ring (in.)	Porous Chrome Ring (in.)	% Decrease in Wear
Ford	100 hp.	3-3/16	0.00036	0.0001	72.2
Chevrolet	85 hp.	3-1/2	0.00022	0.000094	57.3
White	24 A	4-1/8	0.00012	0.000036	70.0
White	24 A	4-1/8	0.00012	0.0000029	97.6
White	24 A	4-1/8	0.00003	0.000014	53.3
GMC Diesel	471	4-1/4	0.00028	0.000067	76.1
GMC Diesel	471	4-1/4	0.00031	0.000048	84.5

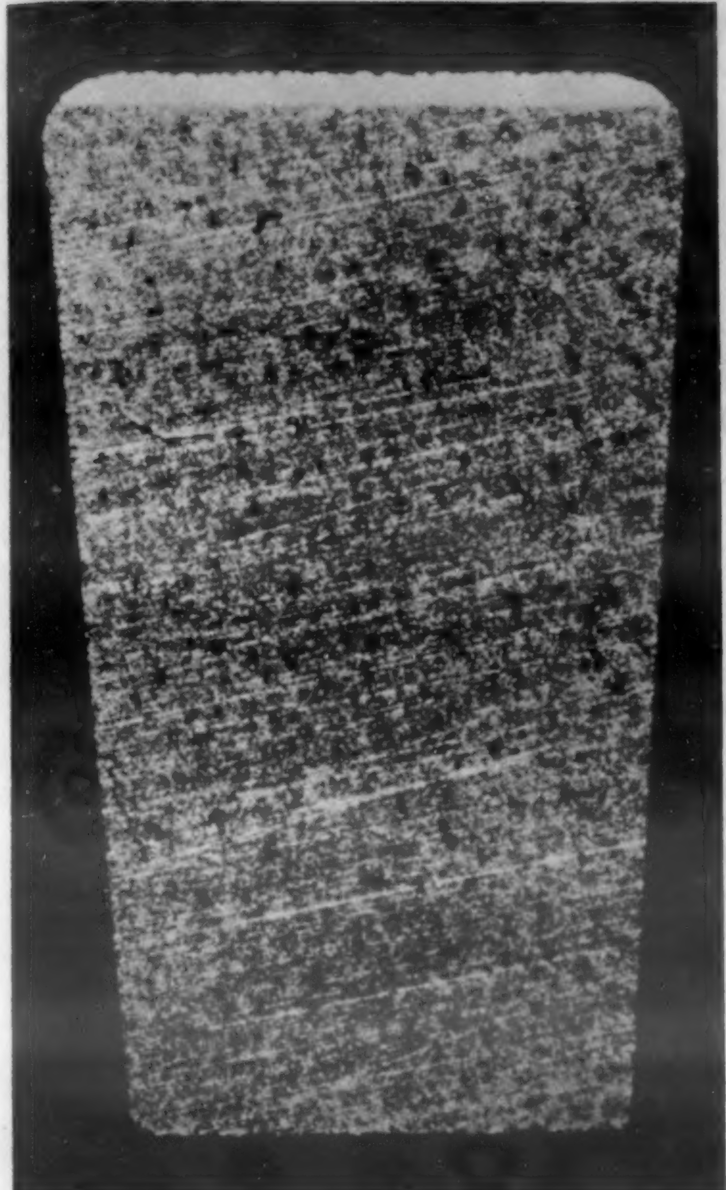


Fig. 7—Porous-chromium plated cast iron ring (25X) shows blending of radius.

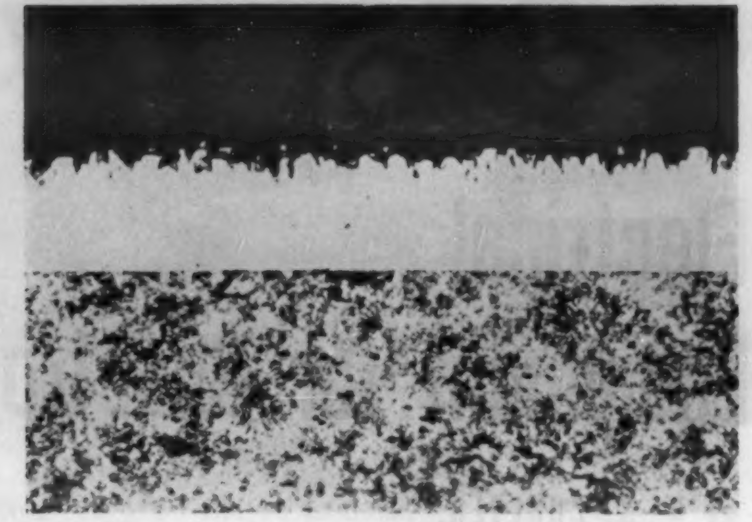


Fig. 8—Cross-section of porous-chromium plated cast iron piston ring (100X, Nital etch).

The finish-honed arbor is then made ready for plating by protecting the collars of the arbors, cleaning the rings by wiping with carbon tetrachloride, assembling the arbors on bus bars, and placing them in anodes (Fig. 4). The centering of the arbor in the anode is important, as the sides of the arbor should be parallel to the sides of the anode. Porcelain spacers and pins are used to keep the arbor centered in the anode.

An assembly of six arbors is placed in the plating tank, the operator then starts the plating cycle. The panel board, shown in Fig. 5, permits exact control through the use of ammeters and voltmeters with indicator lights, making it possible to tell at a glance the plating condition of the arbors and tanks. When all of the arbors are plating properly, a very heavy flow of gas occurs around each arbor and anode assembly, as shown in Fig. 6, where 12 arbors are being plated at one time. Each half of the tank operates from one of the 4,000 amp. generators. This dividing of the tanks makes it possible to do more than one size arbor at a time, as previously mentioned.

After the rings are plated they are separated from each other and then the O.D. edges are carefully radiused. The rings, after radiusing, are inspected for any possible defects that may be present. Samples for each lot are checked for depth of porosity, hardness of plate, and plate thickness. The plate thickness measurements act as a check on the operator who measures the arbors before and after plating. The finished porous chromium plated ring is shown in Fig. 7 and a cross-section of the porosity and plate in Fig 8.

TABLE 8.

TYPICAL RING WEAR RATES USING CAST IRON AND POROUS CHROME RINGS IN BUS AND TRUCK ENGINES

Engine Make	Model	Ring Wall Wear per 1,000 Miles		End Clearance Increase per 1,000 Miles		
		Cast Iron Ring (in.)	Porous Chrome Ring (in.)	Cast Iron Ring (in.)	Porous Chrome Ring (in.)	% Increase in Life
Ford	100 hp.	0.00069	0.00013	.0043	.00082	80.9
Ford	100 hp.	0.00084	0.0003	.0053	.00189	64.3
White	5 A	0.00025	0.00007	.0016	.00044	72.5
White	24 A	0.00025	0.00008	.0016	.00050	68.7
White	24 A	0.00015	0.00008	.0009	.00008	91.1

Electrical Equipment for Spectrographic Analysis

by R. S. COULTER, *Industrial Engineering Div., General Electric Co.*

Proper electrical equipment can save its own cost many times over by reducing furnace operating charges and giving the laboratory more capacity.

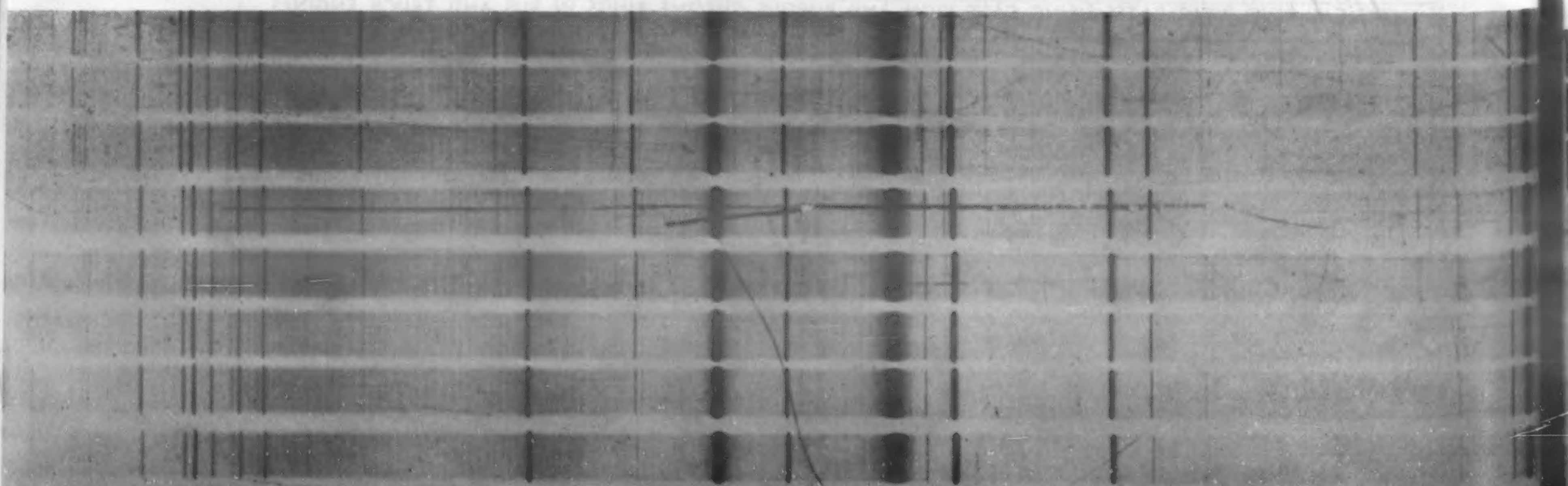
ALTHOUGH PHYSICISTS for many years now have analyzed spectra in order to determine constituents of metals and alloys, the commercial application of the principle by engineers and metallurgists on a broad scale is comparatively recent. However, the results achieved are such that the use of this method of analysis is increasing very rapidly.

In order to obtain a spectrum, a sample of the metal must be heated to an emission point. The sample is usually heated by means of an electric arc (or spark). Two samples of the metal are placed in an electric circuit and an arc is maintained between them. The principal exceptions to this are operating an arc between the metal as one electrode, and a piece of carbon or graphite as a counter electrode, or by using two carbon electrodes, one of which has a crater in which a powdered sample of the metal to be analyzed is placed.

The three general types of arcs used are ordinary direct-current arc, ordinary a.c. arc, and intermittent high-frequency arc. The latter is commonly obtained by means of a tuned high-frequency circuit and is usually referred to as a "spark." Perhaps a better classification would be d.c. arcs, a.c. arcs, and sparks. However, by changing the time constants and other factors of the electric circuit, the characteristics of the spark can be brought closer and closer to those of the a.c. arc.

Part of the emission from the arc is passed through a small slit and into a spectrograph, which is a photographic device consisting of a system of lenses for focusing, prisms or gratings for dispersion, and diaphragms for optical characteristics. It also includes a photographic plate for recording the spectrum. A typical photographic plate is shown in Fig. 2. This particular plate gives results for nine distinct exposures, reading from the top to the bottom of the plate.

The photographic plate becomes a permanent record from which qualitative or quantitative analyses may be made. Sometimes both analyses can be made from a single exposure. At other times, different exposures or plates may be desirable for the two analyses. This may be indicated on the basis of a number of things, such as length of exposure, type



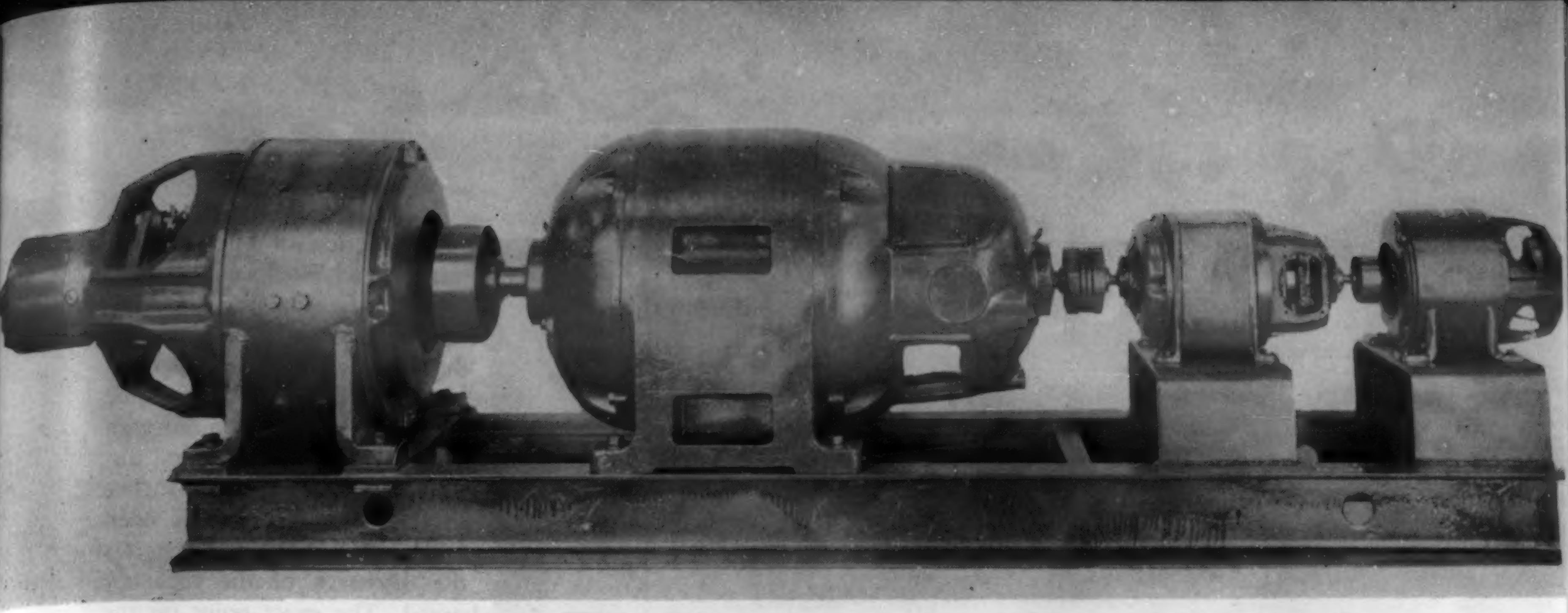


Fig. 1—A typical five unit synchronous motor-driven motor generator set.

of arc being used, etc. The principle involved is that the positions of the lines of the spectrum as recorded on the plate indicate the elements present and the densities of the lines indicate the amounts present.

Spectrographic analysis is suited both to metallurgical laboratories that are primarily interested in testing materials received for fabrication, and to those primarily concerned with the manufacturing control of metals and alloys.

Advantages of Spectrographic Analysis

Advantages of spectrographic analysis as compared with the usual chemical analysis are: speed, cost, accuracy, permanence of records, records of many constituents present that are of no immediate importance but which may require investigation at later dates, and a demand for only a minimum of highly skilled operators.

It is not unusual for a well equipped spectrographic laboratory, when the control of a limited number of elements between specified tolerances is involved, to report an analysis to a furnace or cupola within 8 to 15 min. from the time a sample is received. If the sample is transmitted from the furnace to the laboratory by means of a pneumatic tube, perhaps only two or three minutes should be added to get the total time elapsed from the time the sample is poured until the result is available to the furnace operator.

Costs vary widely. For a well organized laboratory working 24 hr. a day on routine work for furnace control, a minimum cost might be in the order of 15 cents per sample for a determination of four or five constituents.

Accuracies are usually claimed to be in the order of 1%.

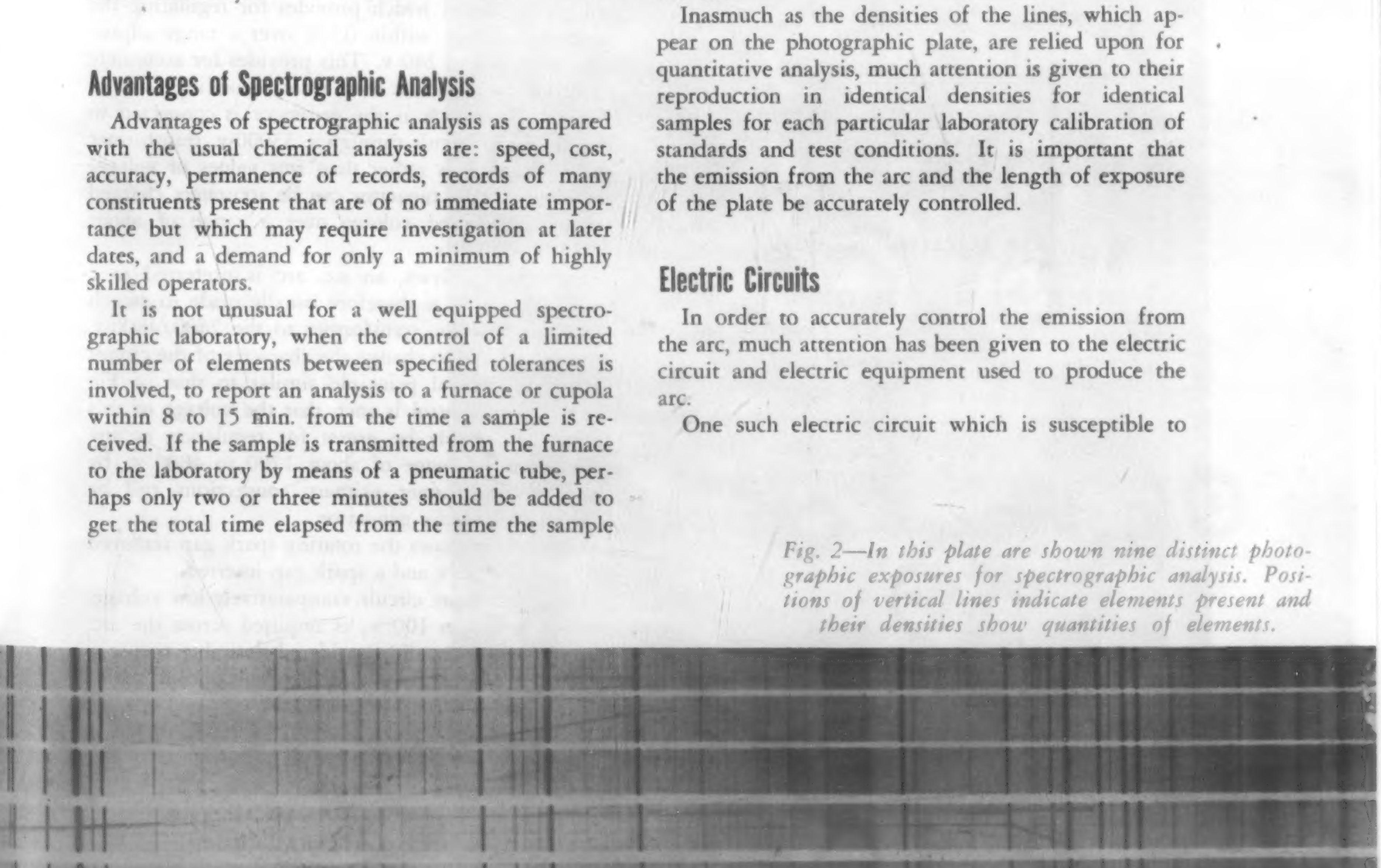
Inasmuch as the densities of the lines, which appear on the photographic plate, are relied upon for quantitative analysis, much attention is given to their reproduction in identical densities for identical samples for each particular laboratory calibration of standards and test conditions. It is important that the emission from the arc and the length of exposure of the plate be accurately controlled.

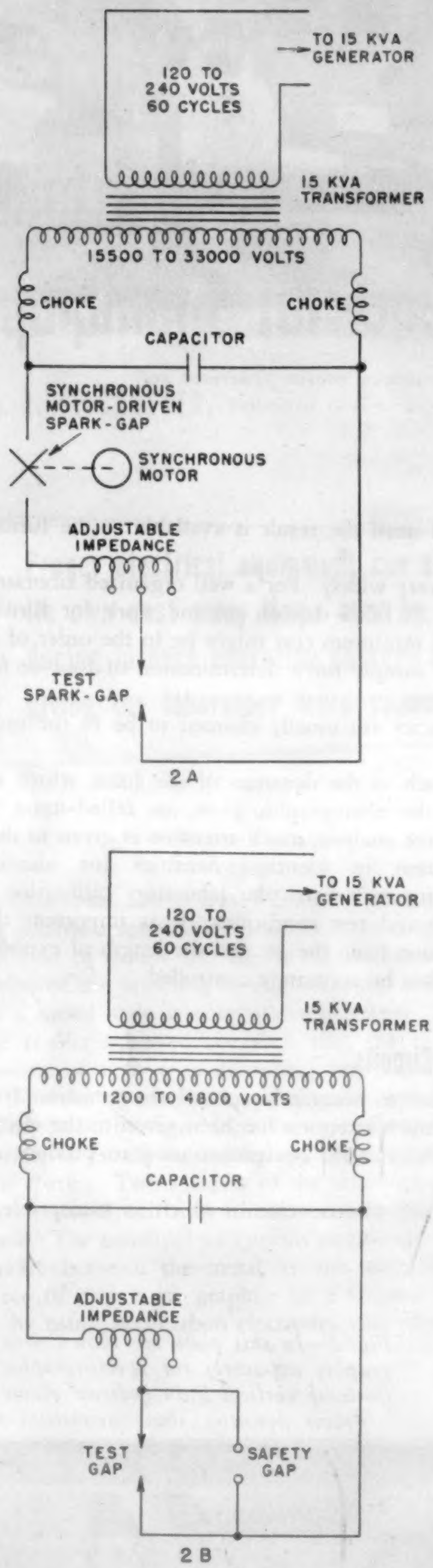
Electric Circuits

In order to accurately control the emission from the arc, much attention has been given to the electric circuit and electric equipment used to produce the arc.

One such electric circuit which is susceptible to

Fig. 2—In this plate are shown nine distinct photographic exposures for spectrographic analysis. Positions of vertical lines indicate elements present and their densities show quantities of elements.





Circuit A (top) is of the high-voltage type for spark operation. When a.c. arc is preferred, the circuit is changed to that shown in B (lower).

accurate control and reproduction of operating results is the Feussner circuit and modifications of it.

A high-voltage circuit for spark operation is illustrated in Fig. 3 (A). Both the a.c. generators and the synchronous motor that drives the spark gap are 4-pole and, therefore, run synchronously at the same speed. The spark gap motor is so synchronized with the a.c. generator that the capacitor charges and discharges during each half cycle of the generator. The rotary spark-gap keeps the discharge circuit open while the capacitor is charging, but rotates into a position to permit the discharge of the capacitor shortly after it is charged. The exact point on the generator voltage wave at which the rotating gap will start the discharge is adjustable by rotating on the motor shaft the moving part of the rotary gap. This adjustment is left permanent after it has once been made.

The discharge of the capacitor appears at the test spark-gap as an ordinary high-frequency damped oscillation. The maximum voltage of the discharge is determined by the voltage at which the capacitor is charged by the transformer, and the frequency and damping of the oscillation is determined by the electric constants of the discharge circuit.

Both of these factors are capable of adjustment. The control equipment is usually furnished with a voltage regulator, which provides for regulating the generator voltage within 0.5% over a range adjustable from 120 to 240 v. This provides for accurately charging the capacitor over a corresponding ratio of voltages. Inasmuch as the generator is connected to the discharge circuit through a 33000-v. transformer and instantaneous rather than rms values of voltage are involved, the capacitor can be accurately charged at any preselected voltage over a range of about 22000 to 45000 v.

For some analyses, an a.c. arc is preferred to a spark. Provision is therefore usually made to switch from the 33000-v. transformer to the 2400/4800-v. transformer and to change the character of the circuit to one in general principle similar to that of Fig 3 (B). The control is such that the voltage of this circuit can readily be preset for regulation at any value over the range of about 1200 to 4800 v., by changing transformer primary connections and by field control of the generator.

This circuit shows the rotating spark gap removed and an impedance and a spark-gap inserted.

In the latter, arc circuit, comparatively low voltage, perhaps less than 100 v., is required across the arc. It is, however, usually considered desirable to use a high-voltage circuit with suitable impedance to maintain a stable arc.

Electric Equipment

The major part of the electric equipment used with Feussner types of circuits includes a 15-kva,

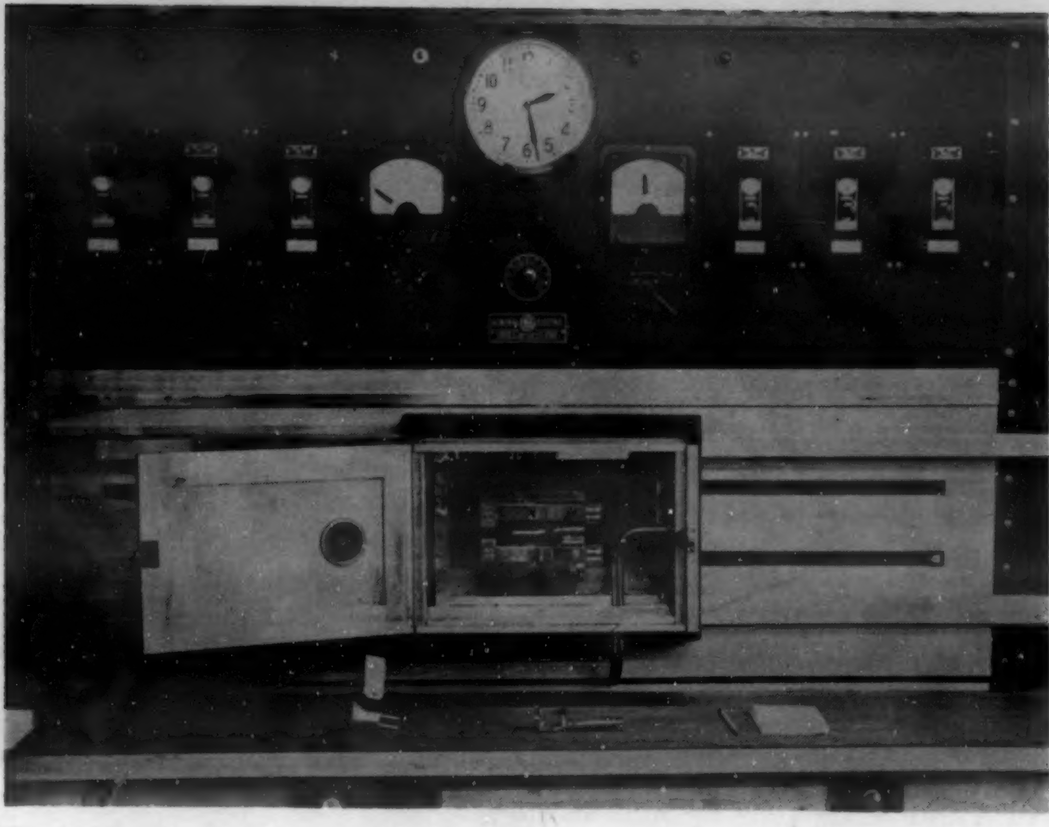


Fig. 4—Master control panels such as this govern operation of the repetitive electrical functions. Automatic timers can be preset as desired.

Fig. 5—Here is an arc-spark relay control panel of the type used in the system described.

five-unit synchronous-motor-driven motor-generator set; a 15-kva 33000-v. Pyranol-filled transformer; a 15-kva 2400/4800-v. Pyranol transformer; a motor-generator control panel; a relay panel; a master control panel; and a synchronous motor for driving a synchronous spark gap. Other necessary elements of the electric equipment are constructed by the laboratory installing the equipment, or obtained through the consultants who design the installation as a whole.

Operations and procedures are carefully controlled in order to get uniform negatives and to save as much time as possible. Some of the more important of these operations involve the length of time the plate is exposed, precautions to let the spark stabilize before the exposure is started, and the time and conditions under which the plate is developed.

In metals production work seconds count very much. It is well worth a considerable increase in investment if a minute or a half-minute can be saved in an ordinary analysis. If, for example, the electric equipment is such that the average negative must be exposed 2 min. instead of one, three or perhaps four dollars are lost during the extra minute for the cost of gas to keep a furnace hot. An extra minute will also materially limit the number of analyses a laboratory can make in a 24-hr. day. For this reason, it is desirable to have as many of the controls as possible within easy reach of an operator and also to have the control to a high degree automatic.

With the usual master panel, an operator can control all frequently required electric operations, including such things as starting and stopping the main motor-generator set, presetting the automatic timing of the exposure, racking the photographic plate up into a second, third, or fourth position to get a series of exposures on one plate, presetting the automatic timing for stabilization of the arc before exposure, changing the value to which the voltage of the generator is to be regulated, and changing the connections of the circuit from spark to arc operation.

The automatic timers mounted on the master control panel, are motor-driven timers that automatically reset themselves after each timing operation. They can be preset to function after any number of seconds up to 2 min. Their specific functions are as follows:

No. 1 timer determines the length of time the arc is to be maintained between the electrodes in order to insure adequate length of exposure without unduly consuming the electrodes. No. 2 timer opens the shutter of the camera for arc operation after the arc has had a suitable time in which to settle down to a stable condition. No. 3 timer energizes a Tesla transformer just long enough to definitely establish the arc across the electrodes. No. 4 timer opens the shutter of the camera for spark operation after the spark has been established sufficiently long to have settled down to a condition of stability. No. 5 timer closes a contactor to finally establish the spark circuit a safe time after a master switch has been moved from the "arc" to the "spark" position. No. 6 timer functions to rack the photographic plate into a new position after an exposure has been completed.

Since many procedures and types of equipment are employed by many laboratories and by various manufacturers of spectrographic equipment, obviously this article applies only to general procedures and the principles of one system.

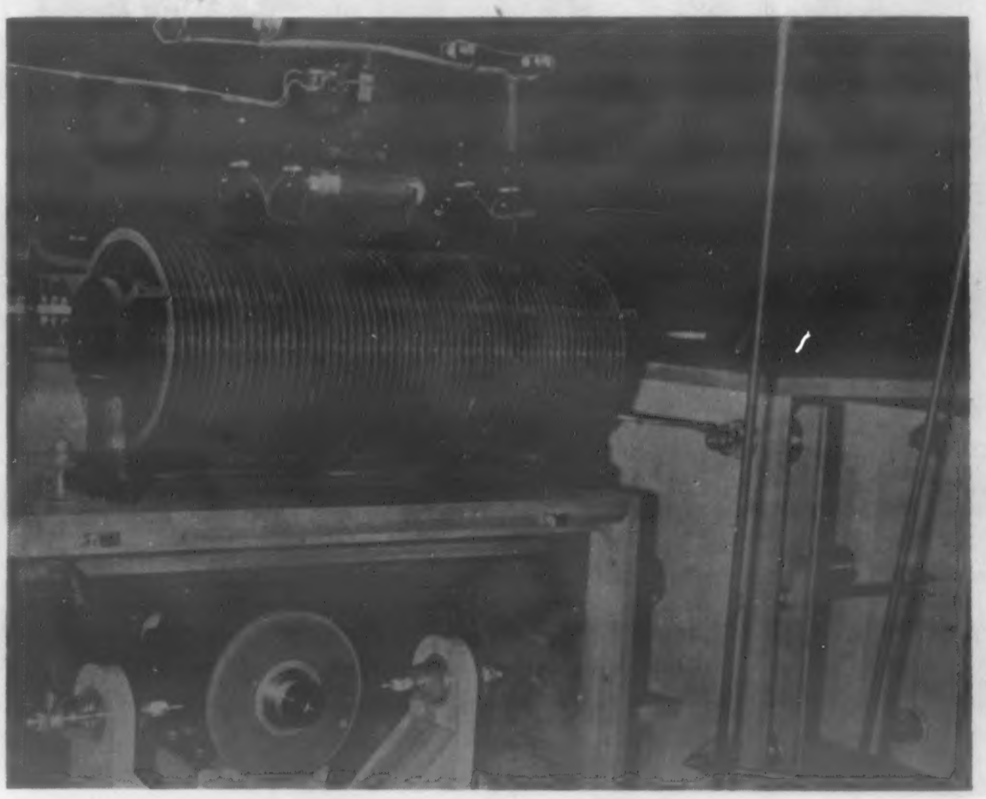


Fig. 6—The synchronous spark-gap is so applied that the capacitor charges and discharges during each half cycle of the generator.

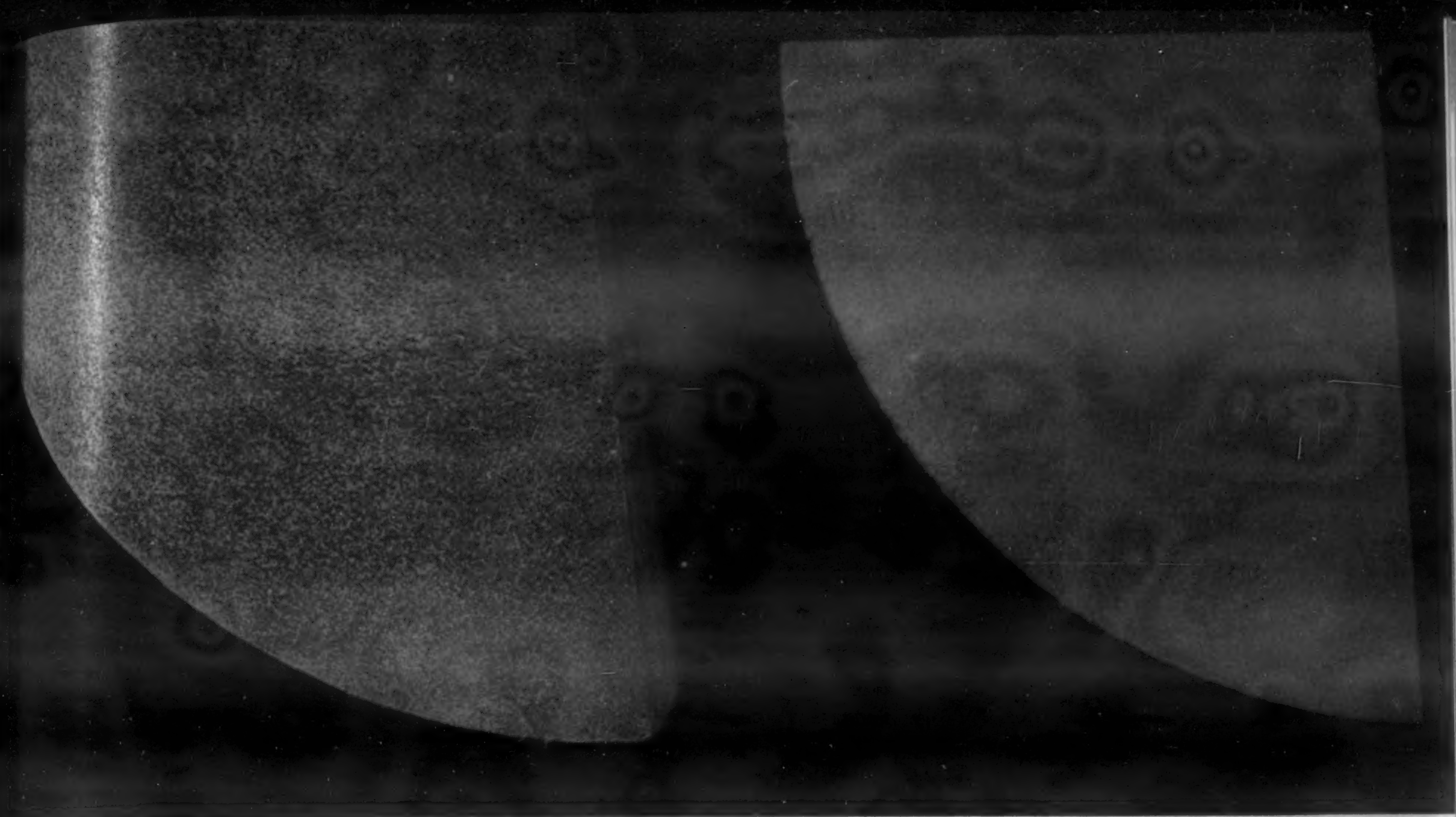


Fig. 1—Results of a deep-etch test on bar stock showed the piece at left to be below standard for aircraft gears.

Precision Production of Steel Aircraft Gears

by ORLO E. BROWN, *Chief Metallurgist, Western Gear Works, Lynwood, Calif.*

THE MOST ASTONISHING industrial advance during World War II was not in production capacity, but in quality of product. A country that once produced 2,000 airplanes a year could produce 50,000 a year by having more plants and more people making airplanes. But to have the 50,000 airplanes of consistently better quality than the 2,000 was a little short of a miracle. It meant the re-education of large numbers of this country's skilled workmen as well as the formerly unskilled. Where sixteenths of an inch had been used, 0.001-in. became common. Accuracy was measured not in thousandths, but in "tenths" (0.0001 in.).

This new emphasis on precision is nowhere better exemplified than in gear making. There is nothing exceptional today about machining to tolerances of the order of 0.0002 in. Aircraft manufacturers and many others have done this on a huge scale for some time. But to make a product which is machined, heat-treated, and assembled in multiple, so that the accumulated error is .0005 or less, does require precision work of the highest order.

Let us consider the amount of improvement which has occurred. While it is not possible to give a specific percentage, since gear performance is not readily compared on such a basis, it can be stated that both large and small gears have shown improvement in accuracy that has permitted greatly increased tooth loadings. It is not uncommon for present gears to be designed to carry from 150 to 300% of the load that gears in the same type of mechanism were expected

Engineering control along the production line helps in achieving the goal of precision gear production with the utmost economy in material and labor.

Fig. 2—Cutting teeth on the main gear for a heavy-duty unit.

to carry in 1930. In this change a large part has been played by alloy steels. By using higher strength steels, gear bulk is reduced, and whole assemblies become lighter, more compact, and more efficient.

While it is not intended to elaborate on the subject of alloy steels, a statement can be made regarding the basis of selection of the steels used. Literally scores of alloy steels have been successfully used in gear making. Since all gears can be classed as light, medium or heavy, it is possible for any manufacturer to standardize on three or four steel analyses, depending upon the duty of the gears. A typical basis for such a standardization follows:

Light Duty—use a carburizing grade of steel, such as SAE 1020 or 8620. Gears are carburized and hardened.

Medium Duty—use a medium alloy steel, such as SAE 4130, hardened before machining.

Heavy Duty—use a higher alloy steel of carburizing grade, such as SAE 3312, carburized and hardened, or a through-hardening grade, such as SAE 4340 hardened.

When a shop has limited its steel stock to three or four analyses, greater heat treating accuracy is immediately obtainable. No doubt the wider employment of "H" steels (those bought on certified hardenability) will make possible a relaxing of the narrow limits imposed on the purchasing department by the specification of only 3 or 4 steels. However, until the "H" steels are more widely obtainable, the gear manufacturer must set up his own specifications for controlling the variables on heat treating.

Not long ago a composite error which included involute profile error, eccentricity, and pitch and spacing error was considered good if of the order of 0.004-in. With higher speeds and loads today, we are meeting specifications for composite error as low as 0.0004-in. Tooth-to-tooth error has also taken a drop to one-fifth its former value. This means precision and control in every step of the processing. Moreover, the added control must be timed with the flow of material so that production is not delayed.

To describe the methods used in one modern plant to obtain precision gears, the subject has been divided under three headings:

1. Control of Material
2. Control in Machining
3. Control in Heat Treating

Control of Material

Before a new lot of steel (be it bar, forgings, or castings) is permitted in the shop, it must have the approval of the laboratory. Both chemical analysis and metallurgical checks are made, so there is every assurance that the material meets specifications. To handle this work, well equipped commercial laboratories are maintained. An example of the value of this preliminary control is illustrated in Fig. 1. The bar on the left is from stock intended for making gears of "aircraft quality." While the chemical analysis and heat treating response were satisfactory, the bar was not up to the desired cleanliness. A new stock (shown at the right) is proven by the deep-etch test to meet the specifications in this respect.

Acceptance of a shipment of steel is only the start of the control in making the part. Sample pieces are tested and checked all during the manufacturing process, so that behavior of the steel is known in advance of each step. The first treatment is that of normalizing the rough blank or stock. When properly done, this results in improved machinability and greatly increased uniformity from piece to piece and lot to lot, which is of considerable importance. In many cases, after rough machining, a preliminary heat treatment is also given. Any such operations are followed by inspections. Fig. 2 shows a rough machined pinion being checked in the Rockwell hardness tester, using a jig to make it possible to take the readings directly on the teeth.

The controls so far described depend upon the laboratory and, in many cases have been used to some extent for a number of years. However, an additional control is essential in precision gear making, and that is control of distortion. In many cases distortion must be eliminated as a dimensional factor. While this ideal is difficult to attain on a production scale, it has been and is being accomplished by coordinat-

ing the efforts of the machining and heat treating departments.

Control in Machining

The subject of accuracy in machining is a study in itself and it is not the purpose of this article to do any more than touch on it as applied to gear making. However, two phases warrant attention in a discussion of precision gearing. First: It is one thing to machine to an accuracy of 0.0002-in., but quite another to produce a finished, hardened gear with that accuracy. By first processing a carefully measured sample gear, it is possible to determine the dimensional change due to heat treating. Whether the change takes the form of growth, spiral unwind, or herringbone angle change, the machining can then be altered to compensate, and the production gears can be held to extremely close tolerances.

Second: It is known that machining operations set up stresses in the metal. When a high degree of accuracy is sought, these stresses become a possible source of distortion which cannot be tolerated. As a result, it is best practice to stress relieve before finish machining, or use the alternate procedure of heat treating in the semi-finished condition. This makes it possible to preserve in the finished gear the accuracy built into it during machining.

Control in Heat Treating

Techniques employed in hardening operations are all designed to limit and control distortion. It is recognized that volume change of the metal cannot be prevented, but by standardizing the change and limiting its direction, uniformity of results is achieved. The tendency to distort is made uniform through successive lots of any one gear by normalizing, stress relieving, and preliminary heat treating operations. Then the dimensional change which does occur in hardening is controlled by quenching in a press. It

Fig. 3—A semi-finished pinion is checked in a Rockwell hardness tester.

goes without saying that during the heating cycle the gears are individually supported and evenly heated, so no warping can occur. When heated through at correct temperature, the gears are withdrawn one at a time and inserted in the die of the quenching press. The die is so designed that it locates the work, trues it to remove all distortion, and then holds it clamped solidly while the quenching oil is forced rapidly through the die to effect the quench. Since the amount of oil flowing through any portion of the die is adjustable, uniform quenching of the entire gear can be obtained with the resulting minimum distortion. Also, the distortion which does occur can be prevented from affecting the bore, or the length, or any other critical dimension by proper design of the dies. Fig. 4 shows a quenching die in place in the press with the gear for which it is used.

Both carburized gears and those made of deep hardening steels are quenched in the press. As in the other operations, a check is run before a production lot is made. This consists of a careful dimensional check of the first gear quenched after changing dies in the quenching press.

A few typical heat treating cycles will help to illustrate how different types of gears are handled.

Gear 1

Part—Helical gear; 10-in. outside dia., 4-in. face, 5-in. bore.

Material—SAE 4620 forging.

Forged blank normalized at 1700 F in a gas-fired horizontal furnace.

Finished machined, except for bore.

Gas carburized for 12 hr. (including diffusion period) at 1700 F in vertical electric furnace. Propane used for carburizing.

Direct quenched in quenching press.

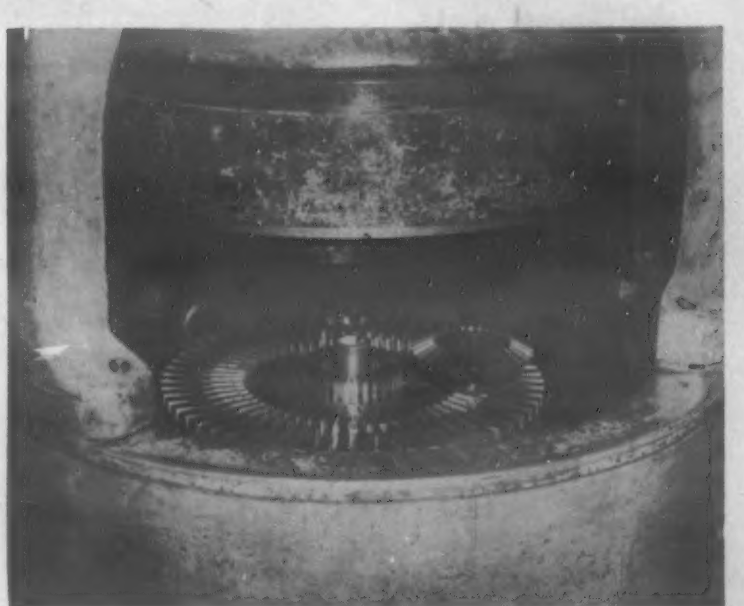


Fig. 4—Quenching die and the bevel gear for which it is used in a quenching press.

Tempered 5 hr. at 350 F in salt bath.

Finished gear hardness: Core, a minimum of Rockwell 26 C; Case, a minimum of Rockwell 61 C.

Gear 2

Part—Low-speed herringbone gear; 26-in. outside dia., 4-in. face.

Material—Modified SAE 4130 casting.

Cast blank normalized at 1700 F in gas-fired horizontal furnace.

Rough machined.

Quenched in oil from 1550 F heated in a gas-fired box furnace with atmosphere control.

Tempered at 1100 F for 6 hr. in the same furnace used in hardening.

Finish machined.

Gear 3

Part—Spiral bevel pinion; 6-in. outside dia., 4-in. face, 30-in. long.

Material—SAE 3312 forging.

Forged blank normalized at 1800 F in gas-fired box-type furnace.

Tempered at 1200 F for 6-hr. minimum in a gas-fired box-type furnace.

Rough machined.

Retempered at 1200 F for 2½ hr. in vertical electric furnace.

Finish machined, except for teeth, and grind stock on bearing dia.

Carburized at 1700 F for 12 hr. (including diffusion period) in vertical electric furnace. Propane used for carburizing.

Cool in furnace as rapidly as possible to 1550 F and oil quench in fixture.

Temper at 1100 F for 2½ hr. in vertical electric furnace and cool in oil.

Finish grind teeth and bearing dia.

Reheat to 1450 F and requench in oil as above.

Temper for 6 hr. at 300 F in vertical electric furnace.

Finished gear hardness: Case, 62 to 64 Rockwell C; Core, a minimum of Rockwell 33 C.

After hardening, the gears go to a vapor degreaser and then to the tempering furnace. A spot-check is used to confirm the previously determined tempering temperature, and also to double check the hardening operation. After the tempering treatment, a light sand-blast or vapor-blast removes the discoloration from the oil quench, and the gears are ready for the finishing operations.

Due to the control which has been given, there is very little metal removed in finishing. The bore can be ground and the teeth lapped. While shaving of hardened teeth can be done, the procedure outlined here makes it unnecessary. The laboratory has taken its place in the production line and has given to gear processing the accuracy of control which makes precision production a reality.

Close-up view of the metal pattern in a pneumatic, roll-over molding machine

Rapid Baking of Foundry Cores by Dielectric Heating

by ROY T. WISE and JAMES P. MORAN, *Induction Heating Corporation*

MANY OLD, FAMILIAR PROCESSING METHODS are proving inadequate under the impetus of keener competition and ever-expanding markets in present-day industry. In foundries, for example, with greater demands being constantly made for higher-quality castings on a mass-production basis, improvement of existing core-making methods has become imperative. The application of electronic heating to the baking of sand cores, developed recently by the Induction Heating Corporation, in cooperation with E. F. Houghton and Company, Inc., has proved itself successful in producing cores of a quality superior to that of cores obtained by conventional methods.

Electronic heating of cores, using thermo-setting binders, bakes them in such rapid speeds that core baking can be done at production-line rates.

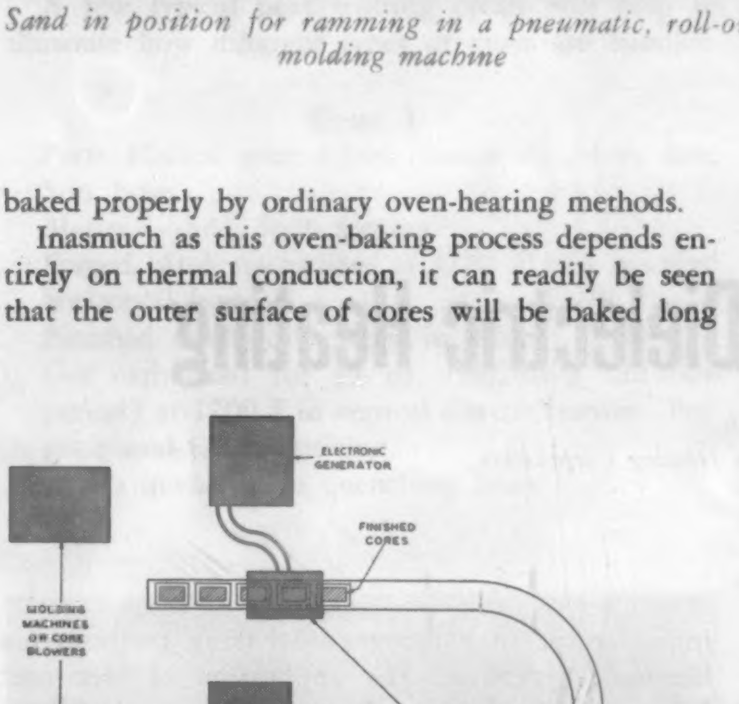
The usual procedure in some foundries today for making dry-sand cores involves the insertion of portable racks, filled with rammed cores, into an oven which has previously been heated up to a given temperature. Since the sand cores to be baked are extremely poor conductors of heat, the heat of the oven penetrates into the interior of these cores very slowly. The thicker the cores, the longer the time required for heat to reach their interior. Thus, in the average foundry, it often takes hours for cores to be

Sand in position for ramming in a pneumatic, roll-over molding machine

Molding machine in roll-over position for drawing the molds from the patterns

baked properly by ordinary oven-heating methods.

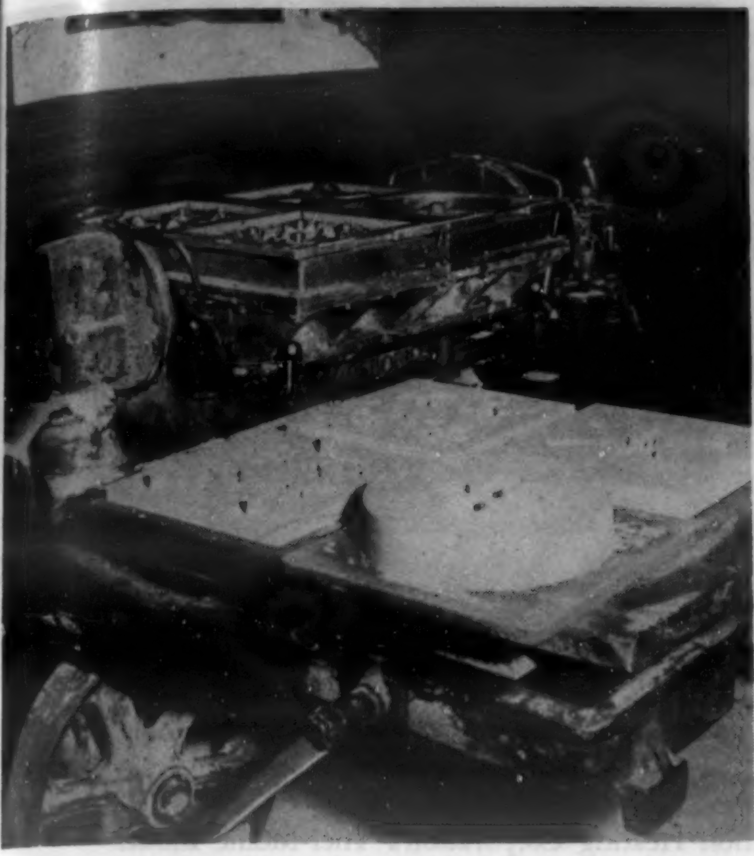
Inasmuch as this oven-baking process depends entirely on thermal conduction, it can readily be seen that the outer surface of cores will be baked long before the interior, with the result that overbaking or burning at the surface often occurs by the time the heat has soaked through to the center. This produces non-uniformity in the entire core structure. Moreover, some ovens have hot spots, resulting in poor temperature distribution, and a consequent uneven baking of cores.



Foundry layout for using three M-700 Ther-Monic dielectric baking units, with conveyors

Ovens in foundries occupy considerable space and much time is consumed in handling cores both before and after baking. For example, a portable rack is usually completely loaded with cores before it is placed into the oven. Likewise, after baking, the rack must be removed from the oven by an operator and rolled to another section of the foundry floor for cooling prior to inspection and subsequent pouring operations.

A mixture of sand, oil, and cereal binder is generally used in cores which are to be baked in an oven. Relatively long periods of time are required by these oil binders for completion of their oxidizing or polymerizing actions. Furthermore, the fumes and smoke produced by the burning of these oil binders during baking and pouring operations are considerable. The gases produced by burning of these oil binders during pouring of the hot metal tend to produce injurious blowholes in the casting. Even when oil is eliminated from core mixtures and thermo-setting binder used, the time required for baking cores in an oven is still a matter of hours because of their very low heat conductivity.



Sand molds completed and ready for baking out in a dielectric heating unit

Molds in position in a Ther-Monic electronic heating unit, prior to baking

Baking by Dielectric Heating

Naturally, in the light of these prevailing conditions, foundries have long been on the lookout for something which would put core making on a production line. With the advancement of high-frequency electronic heating for obtaining uniform temperature distribution in materials which are essentially poor thermal conductors, it was natural to draw parallels between core baking and other processes involving uniform temperature distribution in other poor conductors. It has thus been found that the use of electronic heating equipment to bake sand cores is a solution to this production problem for the foundryman.

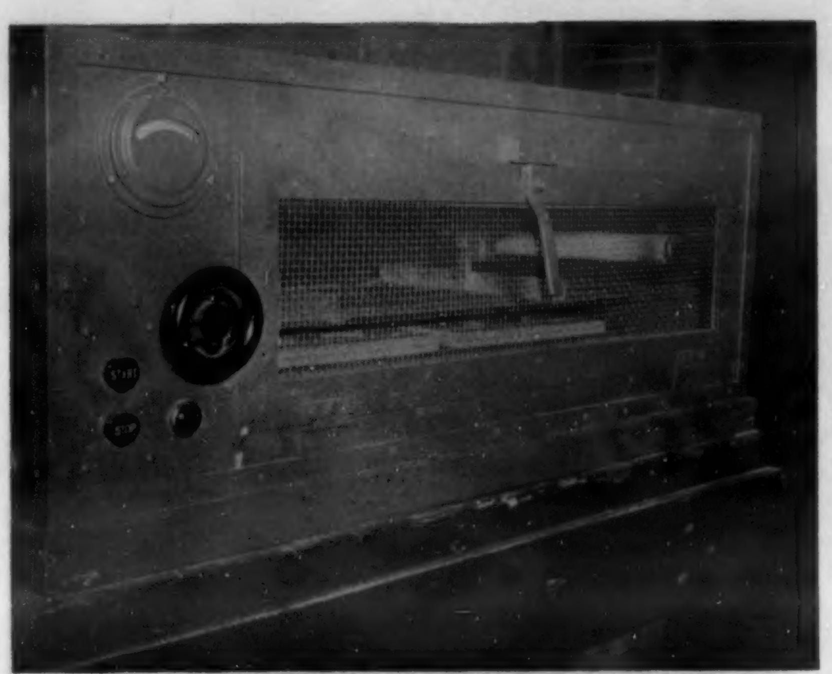
First of all, it was necessary to develop new thermo-setting resin binders for this electronic-baking process to replace the oil and cereal binders usually employed in oven-baking methods. After much research in conjunction with foundries, it has been found that the main point of advantage in using dielectric heating to bake cores made with these thermo-setting binders is the great speed with which finished cores can be produced by this method. Small-sized cores can be baked in as little as thirty seconds, while larger cores take no more than a few minutes for complete baking. The entire process of molding and baking of cores prior to pouring which, by former methods, took hours to perform, is reduced to minutes when dielectric heating equipment is used.

To a person who has not witnessed a demonstration of dielectric heating, these fast baking times may seem unbelievable or exaggerated. However, these are actual production times, recorded in a large Eastern foundry, where this modern, electronic baking process is being applied.

Consistently uniform baking of cores is an inherent characteristic of this new foundry process. It is, moreover, possible by this means to have line production in the core-making department of any foundry since cores coming out of a molding machine can be placed directly on a conveyor leading into one of these new electronic baking tunnels. This eliminates handling time and delay due to insufficiently filled racks, which are typical disadvantages of oven-baking methods. Cores are speedily and uniformly baked by heat produced by high-frequency currents and are then moved along a belt system onto an inspection table.

There is no possibility of burning or underbaking cores by dielectric heating since the speed of the conveyor is set at a predetermined rate, so that each core receives just the right amount of heat needed to insure proper baking.

The guess work and trial-and-error results of ordinary oven-heating methods are done away with by the use of electronic baking installations, equipped with automatic-timing devices. Unlike conventional ovens, dielectric baking equipment requires no heating-up time and subsequent stand-by losses when the equipment is not used. These units are instan-



Molds in a Ther-Monic baking unit during baking

Sand molds stacked and ready for pouring

taneous heaters, supplying heat only when heat is needed. The space savings in a foundry brought about through use of such equipment are considerable. Energy costs are lower and equipment costs are comparable to costs of conventional ovens. These units, moreover, lend themselves to short as well as long production runs.

Quality and Cost Advantages

According to tests made by a large manufacturer of castings, dielectrically baked sand cores are better in quality than cores cured by the usual oven methods. Since electronically baked cores have a low organic content, they give off less gases at the time of pouring. This reduction of volatile matter lessens the possibility of blowholes occurring in castings. And less blowholes in castings mean fewer rejections and stronger castings.

This new method of baking dry-sand cores by means of dielectric heating produces heat on an entirely new principle and with a uniformity and speed heretofore unattainable. Instead of creating a higher temperature at the surface of cores, as in the case of ordinary oven baking, dielectric heating distributes heat uniformly throughout the mass of every core which is placed in its high-frequency field. Each unit mass of every core thus receives the same amount of heat energy. Because of this ability of dielectric heating to bake poor thermal conductors, such as sand cores, evenly and speedily all the way through, it is thus possible to bake cores of large cross-section rapidly with a consequent minimum of rejections.

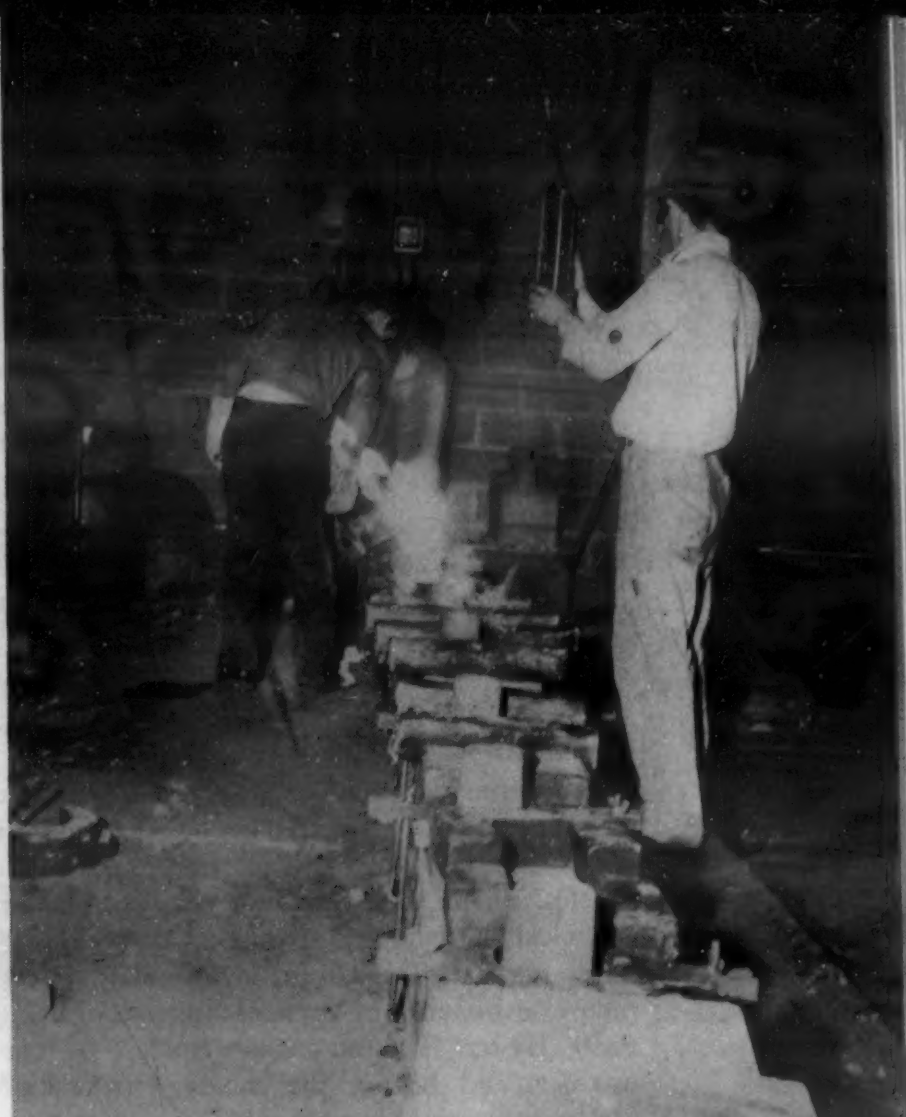
In regard to costs of operation and productive capacities of dielectric heating installations in a typical foundry, a dielectric baking unit such as the Induction Heating Corporation's Ther-Monic Model M-700, is capable of baking approximately 360 pounds of dry-sand cores per hour. Actual foundry production records show that the power consumption for a unit of this type averages not more than 25 kilowatt-hours per hour; at a power rate of one cent per kilowatt-hour, the hourly cost of operation would be 25 cents. Larger production rates can easily be estimated from these figures. For example, a plant running 24 hours a day and using four dielectric heating units of this type, having a power output of 12 kilowatts each, would be capable of producing approximately 17 tons of baked dry-sand cores per day at a power cost of only 24 dollars.

Maintenance requirements on these dielectric heating generators are exceptionally low. Power tubes used in this equipment have a life expectancy of from 4,000 to 6,000 hours. When necessary, tube replacements can be made quickly by the plant engineer. These dielectric heating generators have proved themselves practical machines for factory use. In the fields of induction and dielectric heating, thousands of such units are being used in daily production in plants throughout the country.

Thermo-Setting Resin Binders Used

The excellent results obtained by the use of dielectric baking equipment are made possible only through the use of thermo-setting binders in core mixtures. These quick-setting binders are of the synthetic-resin type and can be mixed with sand uniformly and speedily in an ordinary muller. In mixing the components for sand cores, the dry thermo-setting binder is added first to the sand. This combination is mixed for about two minutes, until the binder is thoroughly

Tapping heat into a ladle ready for pouring



Pouring of molten metal from a ladle into the stacked molds

dispersed in the sand. Then water is added, and mixing continued for about one minute. Cores can now be formed from this preparation of sand, binder, and water.

Extensive tests were conducted in conjunction with the technical staff of a large foundry for the purpose of determining the best mixture for dielectrically baked, dry-sand molds to be used for small castings. Results of these tests showed that the following formula gave the best results for their work:

400 lbs. of 60-70 Mesh Wedron Sand.
20 lbs. of Houghton #250 Hy-ten Thermo-setting Binder.
8 quarts of Water.

Silica flour may be added to this mixture to obtain a smoother core surface; cereal binder may be added if additional green strength is desired. In either case, the addition of these constitutents requires additional thermo-setting binder. This will not introduce porous weakness into the baked core.

Among the benefits to be derived from the use of dielectric core baking is the fact that thermo-setting binders can be used to full advantage in this process. The following advantages offered by this ideal combination of electronic baking and thermo-setting binders are especially important to the foundry industry:

1. *Good green strength without cereal binders.*
2. *Rapid, uniform baking at low temperatures*—Automatic timing on Ther-Monic Dielectric Heating Units insures the maintenance of a constant baking temperature and prevents overbaking or underbaking, and resultant reduction of core strength.
3. *High core production rates*—This factor alone means considerable savings in the foundry through improved efficiency and greatly increased core-baking capacities.
4. *Minimum gas production during pouring*—Cores made with thermo-setting binders and baked by dielectric heating have a low organic content and hence produce little gaseous matter at the time of pouring. Blowholes in castings, a major cause of casting rejection, are thus minimized.
5. *High surface hardness and tensile strength*—Uniform electronic baking of sands mixed with thermo-setting binders consistently produces hard, firm cores, which will not break during handling or wash away during pouring of the molten metal.
6. *Good collapsibility and shake-out characteristics after pouring and solidification.*—Good collapsibility helps to eliminate cracks, hot tears, and strains in castings during contraction of the metal. Good shake-out produces a cleaner casting, thereby cutting subsequent cleaning costs considerably.
7. *Dimensional stability*—Dielectric heating minimizes expansion, contraction, and distortion of cores, thus insuring greater dimensional stability.

8. *Elimination of oil fumes and smoke*—The use of electronic baking and thermo-setting binders eliminates irritating oil fumes and smoke which characterize conventional oven baking.

9. *No lengthy cooling-off periods required.*—After dielectric baking, cores made with thermo-setting binders do not require long cooling-off times, and pouring of the molten metal can thus occur immediately after baking.

Baking Dry-Sand Molds for Small Castings

In a series of production runs in a large foundry, making small alloy castings in dry sand molds, it was found that dielectric baking of the molds resulted in a definitely improved, quality output. The practice is typical of that used in baking cores by the electronic method. The accompanying photographs show the process of making these castings, using Houghton #250 Hy-ten Thermo-setting Binder in the sand mixture, and baking the molds with Ther-Monic dielectric heating equipment, specially designed for this purpose.

As soon as the molds were made in the molding machine, they were immediately placed in the dielectric baking unit. These molds were baked dielectrically at the rate of 2½ to 3 pounds a minute with a Model M-285 Ther-Monic dielectric heating generator, having an output of 5 kilowatts. It was possible, by this means, to eliminate a wait of from two to four hours between baking of the cores and pouring of the molten metal.

This process proved to be entirely feasible from an economic standpoint. Molds which required approximately one hour of baking in conventional ovens, were baked by dielectric heating in from 30 seconds to one minute. Less breakage occurred after dielectric baking, and over-all physical characteristics of the dielectrically baked molds were equivalent to and, in most cases, far better than those obtained by the usual oven methods employed at this foundry.

Because of the successful results obtained by dielectric heating equipment at this large foundry, research engineers, in conjunction with foundrymen, were able to develop an efficient production-line system for producing dry-sand cores and molds of good quality much faster and more efficiently than has been thought possible up until now.

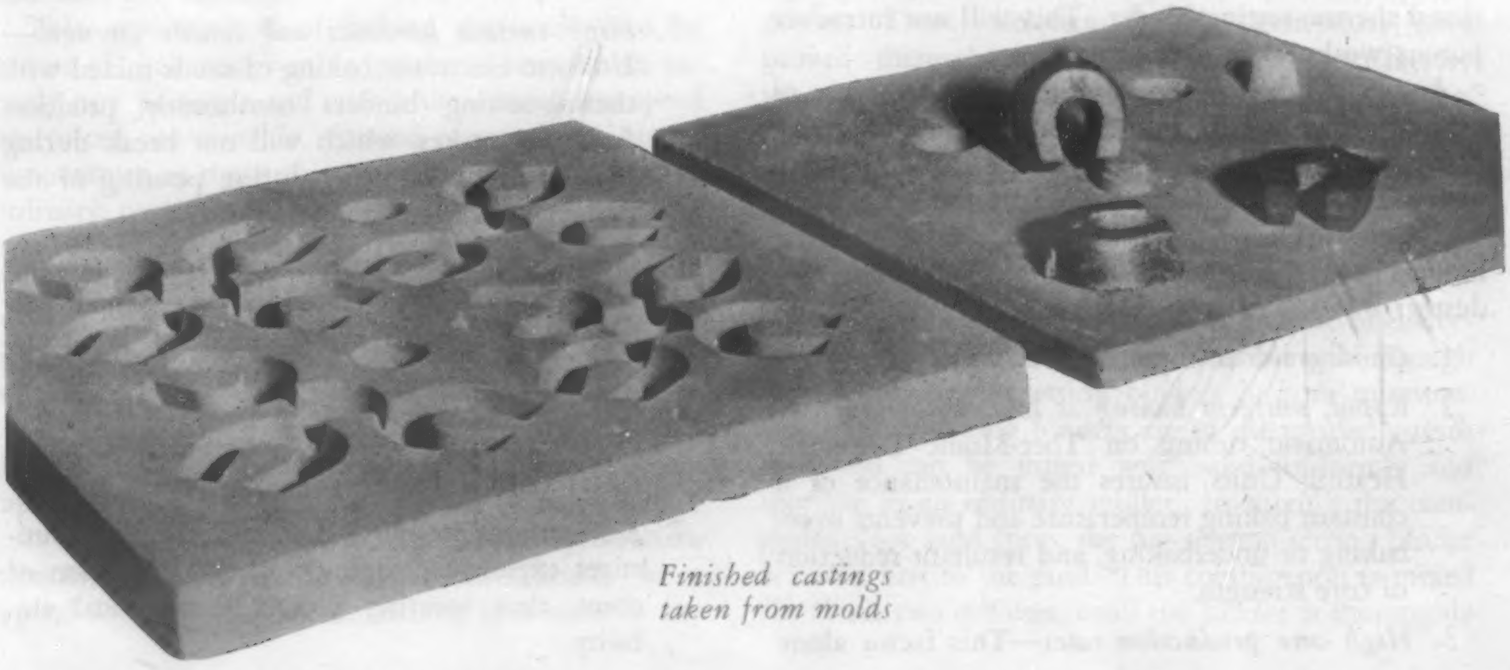
A plan of this typical production-line system is shown in the diagram. Three molding machines or core blowers feed sand molds directly to three belt-conveyor systems. The molds pass through a dielectric electrode tunnel on a conveyor running at a predetermined rate of speed, are baked uniformly throughout their mass, and then pass on to a roller track which conveys them to a single inspection table.

The making of cores thus becomes a rapid and uniform process, in which results are predictable and a previously serious reject problem is eliminated.

Baking of cores made with thermo-setting binders by dielectric heating in all respects meets the current pressing demands on the foundry industry for increasingly rigid controls on core quality and conformity to casting dimensions. The initial cost of installing dielectric heating equipment in a foundry is soon offset by the many savings made possible by the use of this modern electronic baking process.

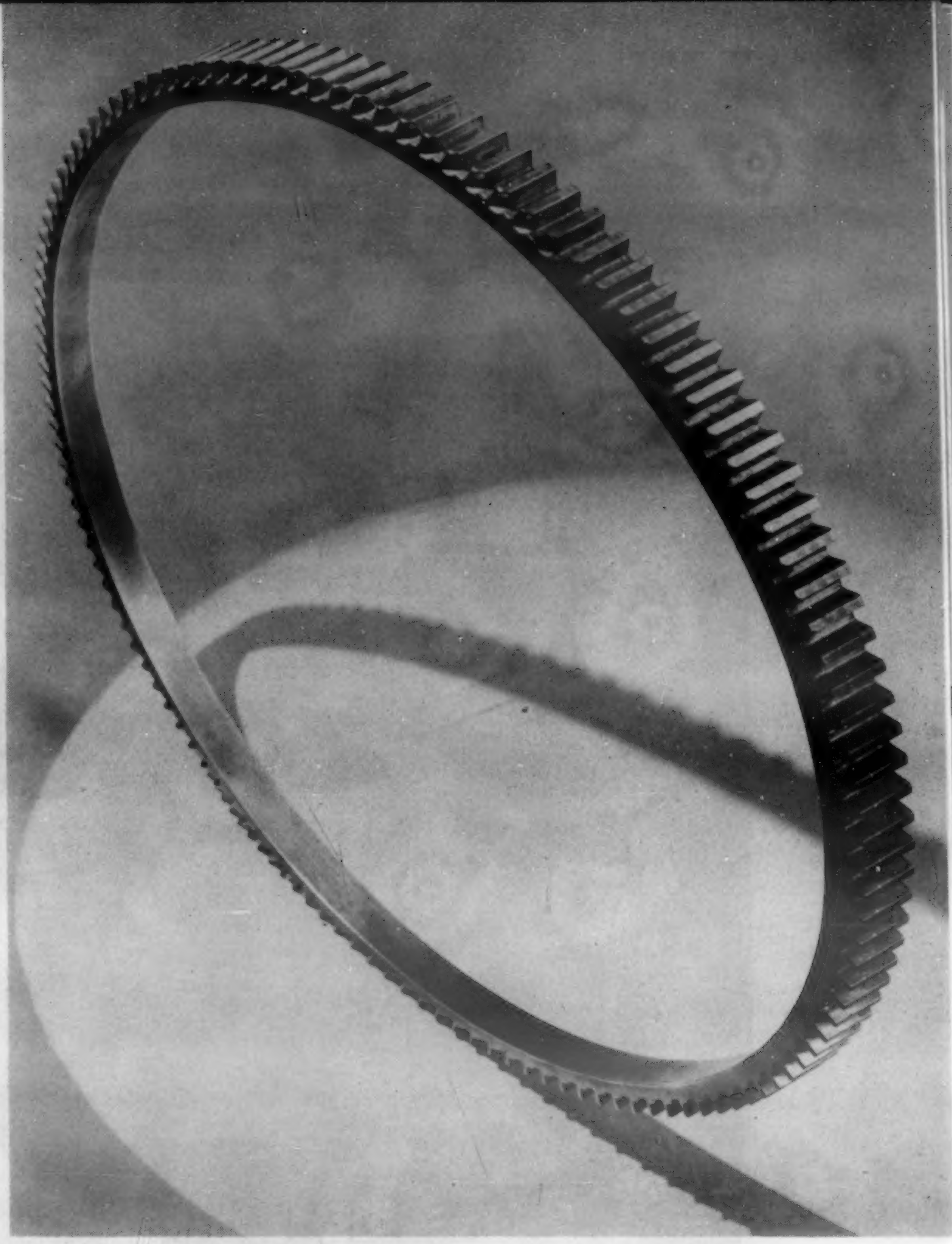
Acknowledgment

The authors wish to express their indebtedness and appreciation to Mr. George Muntz, Jr., Project Engineer of the Induction Heating Corporation, for his technical advice and invaluable assistance in the preparation of this article.



Finished castings taken from molds

As one means of reducing unnecessary material handling, heat treating is now moving into the production line. Here is a recent example of this new trend.



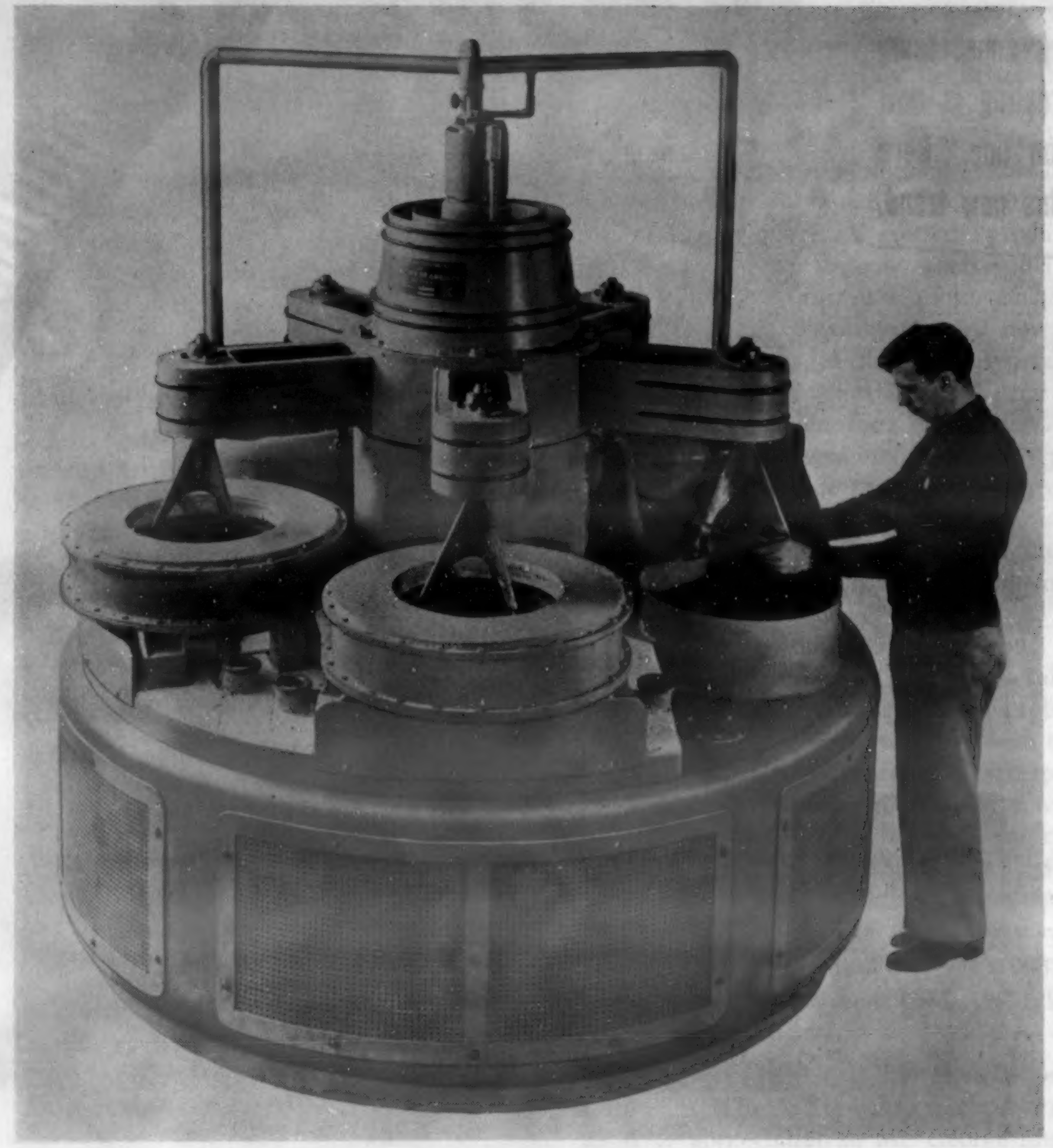
Through use of a gas heating, machine gears of this type are hardened at the rate of 180 per hr. Material used is SAE 1045 steel.

High Speed Heating with Gas Provides Heat Treat Tool

by C. W. EIGENBROT, *Selas Corp. of America*

SPECIAL RESEARCH PROJECTS of recent years—concerned with advancements in high speed heating—have resulted in the development of a new concept of heat treatment and a new type of heat treatment equipment. This new concept involves the transfer of a particular section of the heat-treat department to a specific location in the production line —in the form of a "machine tool for heat treatment" —in line with the grinder, the miller, the press. This new concept points to advances in control, uniformity, speed, work handling, and metallurgical exactness—and, in addition, puts the heating process in step with the rest of production.

In gas heating, the research projects which have



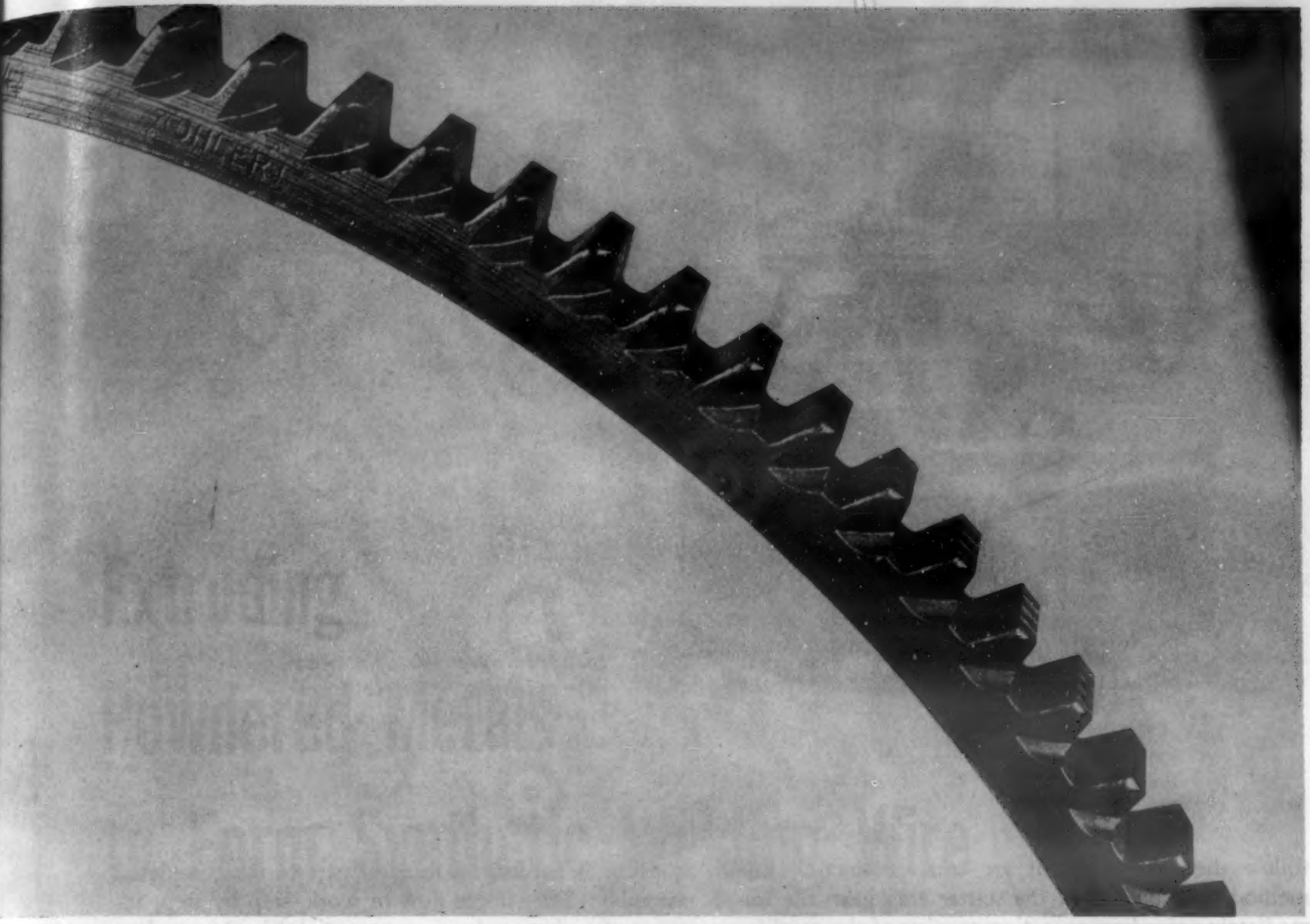
The operator's only duty is to load and unload gears. With this exception, the entire operation is automatic.

led to this new class of machinery have depended upon the development and perfection of special combustion techniques. These techniques include "ratio-supercharging" (complete premixing and pressurizing of the fuel), "ceramic-supported combustion" (utilization of radiant surfaces to promote combustion), and "function-fitted combustion" (using heat as a basic tool and building equipment around it). All of these techniques have contributed to the perfection of a new heat treat tool now being used for the hardening of starter ring gears in the automotive industry.

The automotive starter ring gear, due to the compression on the motor as it stops, wears out in one of three different places. Therefore, the gear must be hardened precisely and uniformly. While this hardening machine is considered to be universal (with minor changes in burners and work fixtures) it is, at the present time working on a standard size 14.625-in. O.D., 10 diametral pitch gear with a ½-in. face and a pitch diameter of 14.6-in.

The heat source consists of two special burners of the "superheat" type. They are ring shaped with a restricted outlet slot on their inside faces, so that the gear indexes down inside the burners and is totally encased in high velocity streams of hot products of combustion. There are a total of 5 index stations on the machine—one for loading, two for heating, one for quenching and one for cooling. Indexing is hydraulically operated, responding to automatic controls which determine the time-temperature treatment of the gear.

The machine itself is circular in shape, has a maximum diameter of 7 ft. and an overall height of



This enlarged view shows a 14.625-in. gear which remains under the heating burners for 12 sec.

7½ ft. It is completely automatic (with the exception of loading) and self-contained and operates on a complete premixture of gas and air.

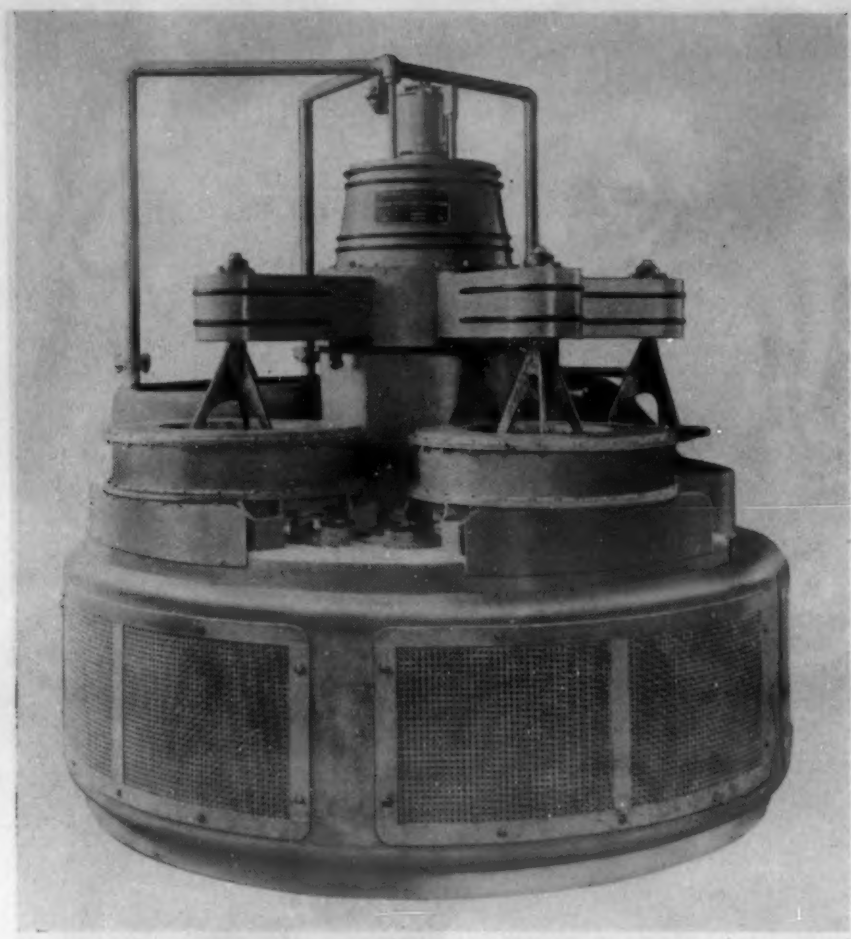
Present production is at a rate of 180 gears hardened per hour, which means that each gear rests within each of the two burners for 12 sec.—to attain a temperature of 1500 F—and takes 8 sec. for indexing from burner to burner, burner to quench, quench to cool and cool to unload.

A minor change in equipment, without change in essential features of design and operation, will permit an increase in production to approximately 360 ring gears per hr., per machine—with one operator. Burner #1 consumes 7,600 cu. ft. of mixture per hr., while burner #2 consumes 10,200 cu. ft. of mixture per hr. Thus, with completely premixed and pressurized fuel, with the compacted combustion of ceramic slot burners, and with precise heat localization, this starter ring gear completes the hardening cycle in just 40 sec.—obtaining a local hardness of 60 Rockwell C on the pitch line of the tooth, 59 C at the root of the tooth and 40 C on the inside gear diameter. Quenching is accomplished with oil—and includes a submerged spray for rapid agitation. The oil is cooled by internal, circulating water, coils.

The gear, in passage through the various stations, is held by a three point spindle which rotates in every station except loading. The indexing includes the circular motion from station to station and an up and down movement on a central cam as the part is placed in the working position of each station. Indexing and lift is accomplished with one single operating mechanism—one hydraulic cylinder.

Among the advantages of this type of equipment should be listed the efficient BTU realization from such heat localization, and the precise control and uniformity coincident with delivering to each and every work-piece the exact same time-temperature treatment. Further, work handling is reduced to a minimum (since there is no longer the necessity for the transfer of the work-pieces to a separate, removed, heat treat department) and metallurgical specifications can be exactly matched through absolute control of normally varying factors.

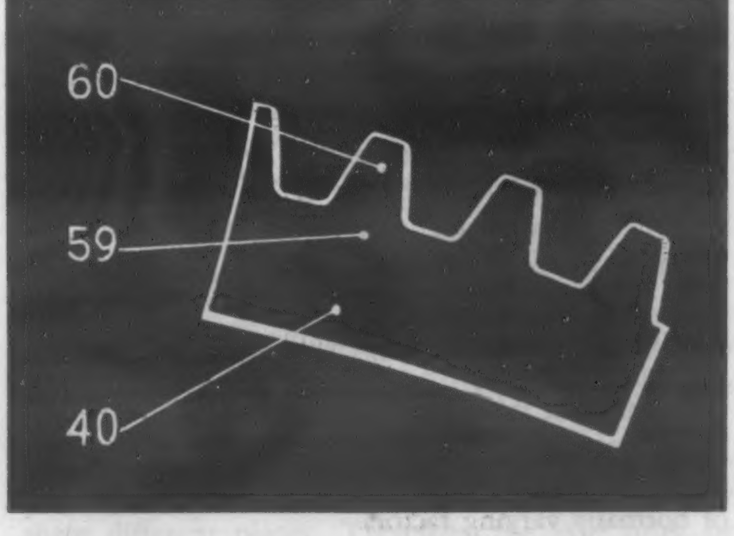
Proof that such equipment is a "heat-treat-tool" lies in the fact that the operations which precede and

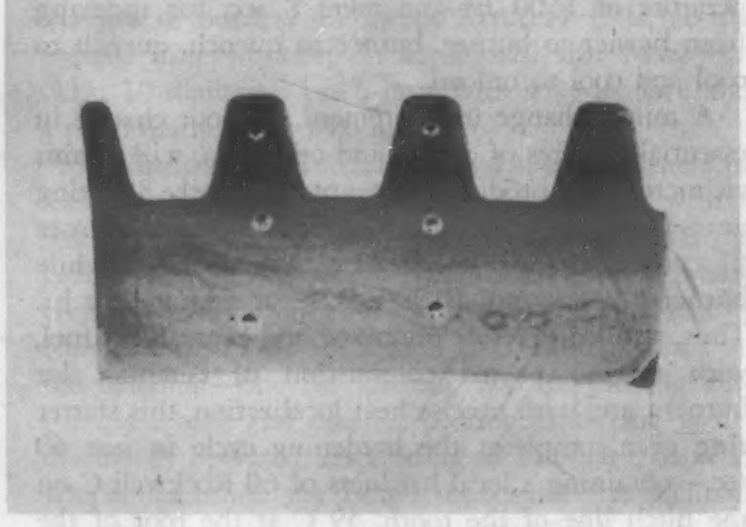


In appearance, the heat treating machine resembles some types of machine tools along with which it works.

follow the heat-treatment are true, production line methods. In the case of the starter ring gear, the immediately preceding operation consists of the machining of a bevel on one side of the gear teeth—from the pitch line to the root. The gear then, staying right in the production line, is placed in the flame hardening machine. After hardening, the gear is expanded by the application of heat to the inside surface, and is then shrunken onto a formed-plate housing to become an integral part of the completed assembly. The simple flow of work, step by step, accounts for time and money economies in the production of such complete assemblies—and the heat-treat operation is one of those steps.

Such equipment, producing so many uniform pieces with savings in initial and operating costs, is a distinct advancement in the art of heat treatment and an asset to the modern production line.





Hardness ranging from 60 to 40 Rockwell C is attained on the gears as indicated on the cross-sectional view and drawing.

A drawn-wire base is clad with alloying elements in much the same manner as rods are flux-coated to produce special application welding rods.

Extruding Powdered Metals to Form Synthetic Welding Wire

by F. G. DAVELER, *Associated Industrial Engineers, Inc., Philadelphia, Pa.*

THE USE OF POWDER METALLURGY, to form machine parts that are difficult or impossible to produce by conventional methods of casting or machining is well known and quite widely accepted.

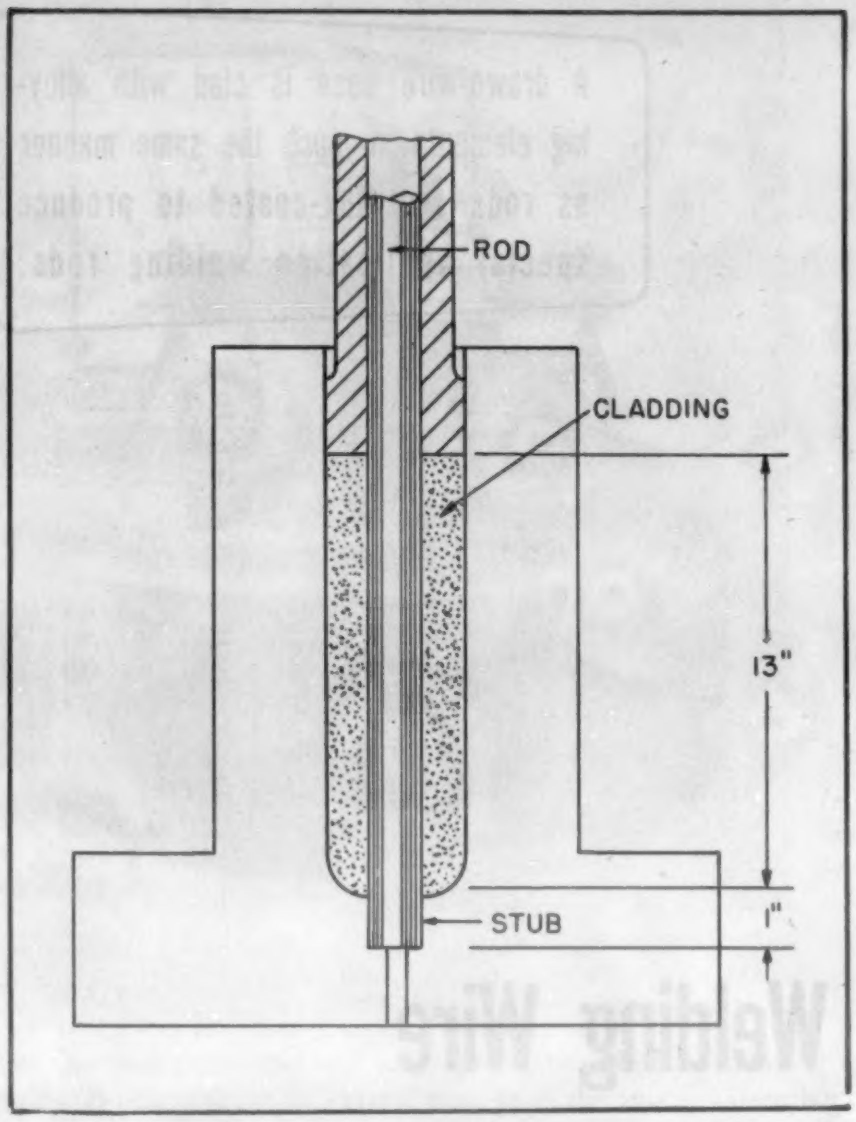
Generally speaking powder metallurgy consists of selecting the desired materials as to chemistry and particle size and pressing the metal grains in a die the exact size of the desired finished piece. The pressures used to make many of the powdered metal compacts vary considerably, sometimes exceeding 75,000 pounds per square inch, depending upon the material used. After compacting, the pieces are sintered in an atmosphere controlled furnace at temperatures approaching the melting temperature of the powder. Sintering, again generally speaking, is a molecular reaction which due to the pressure and high temperature fuses or welds the tiny particles to each other.

The engineering staff at Associated Industrial Engineers, Inc., has for a number of years acted as consultants, designers, and manufacturers of equipment for the compacting and sintering of powdered metal products, and in addition has designed and built processing equipment for the welding rod industry.

Some time ago Associated Engineers conceived of a method of producing, through the media of powder metallurgy, an alloy welding rod composed of a drawn base wire clad with alloying elements over which is coated a flux covering. The desire to produce this new type wire, economically, paved the way for the development of a method of extruding powdered metals and compacting them around a wire in much the same manner as that now used in flux coating welding rods.

Heretofore powdered metals were considered immobile, resulting in the confinement of powdered metal compacts to those in which the particles moved only in one direction. The development of a method of extrusion in sufficient density to permit sintering opens the door to means whereby powdered metals can be made to fill a complex mold wherein the metal powders will flow around corners and into voids.

In the welding field the extrusion of synthetic alloy wire will fill the need for an inexpensive method of producing wire alloyed with elements that make it difficult or impossible to produce by either hot or cold rolling and drawing. The finished synthetic rod



By the method described welding rod can be produced to match many analyses of stainless, tool steel and other types of alloys.

is capable of being coated with the usual a.c. or d.c. welding rod fluxes and used in arc welding in the same manner as any coated rolled and drawn welding rod. The finished unfluxed synthetic welding wire presents the appearance of a rod coated with a dark metallic-appearing case. Actually it is a small diameter base wire encased within a cladding of powdered metals.

Synthetic Rod Production

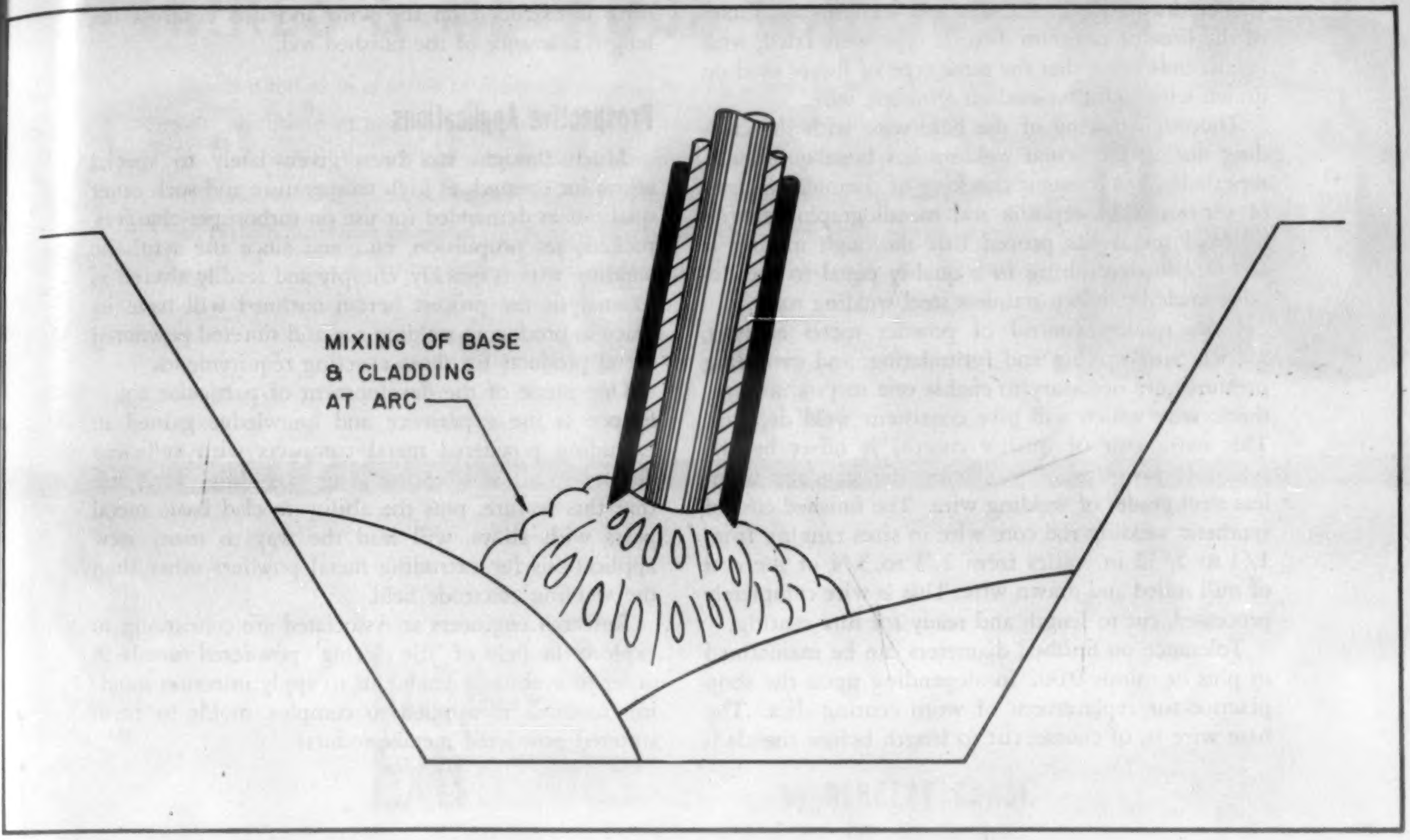
In making synthetic stainless steel grade of welding wire, a base wire of ingot iron is clad with sufficient powdered chromium, nickel, manganese, and silicon to combine under the welding arc with the ingot iron base wire to produce a weld deposit of standard stainless steel. A 5/32 in. dia. base wire clad to a finished diameter of 0.249 in. (¼) will produce approximately this analysis. There are endless possibilities available in any conceivable analysis by varying the quantity of cladding to the quantity of base metal.

Many other analyses of stainless, tool steel, corrosion resistant, hard facing grades, etc., can be produced. Variations from the standard analysis can be obtained by varying the ratio of base material to clad material, or, which is more important, by varying the density of the cladding.

The density may be varied from a fraction of drawn steel density to almost full drawn steel density by varying the pressure exerted on the powdered metal compact around the base wire. Another method of altering the density of the cladding is to vary the quantity of lubricant used to aid in the flow of the powdered metal particles.

Early attempts at getting the powdered metals to adhere to the base wire and to form a smooth even case were alternately discouraging and heartening. Equipment was difficult to obtain and to add to other difficulties few of the rules for producing normal powdered metal compacts were applicable.

Most of the first test rods were made by pressing the metal powders around short lengths of mild steel wire by the use of a press in which the base wire passed through the piston while the powders were being compressed. The results from this method of production were only fair, particularly in view of the fact that the process was slow and the yield low. It



When the base rod and the alloy cladding mix during the welding they produce a weld deposit of the desired type.

did serve however to lay the ground work for determining particle size requirements, sintering characteristics, and weldability of the finished product.

It took many months of concerted effort to find that the metal powders, if properly selected for particle size and mixed with a suitable lubricant could be readily extruded as welding rod fluxes are now extruded on drawn welding wire. Next the proper lubricant and binder had to be found, a filler which would not alter the welding characteristics, and a binder which would volitalize out of the compact at some point below the sintering temperature.

Sintering

Many lubricants were tested in order to find the combination that produced the two essential features desired, that of aiding material flow during extruding and allowing the low temperature partial sinter to take effect.

The original sintering cycles were long and at relatively high temperatures, but experience showed us that thorough sintering, as considered in the manufacture of powdered metal machine parts, was not necessary, and that synthetic welding wire required just sufficient bond to give the rod strength and durability to withstand normal abuse. This brought the process down to a very economical low temperature short cycle operation.

Oxidation of the cladding during the hardening treatment required the use of controlled hydrogen atmosphere in the furnace.

Hydraulic pressures exceeding the normal pressures used in extruding welding rod coatings were found necessary to extrude powdered metals with sufficient finished density to allow sintering and to prevent the flaking off of the cladding during welding. This requires the use of special dies and hydraulic presses built for high pressures.

Flux Coatings

After welding tests were made on the first samples produced, it appeared that a special flux formula might be necessary to overcome some of the unorthodox welding characteristics of the synthetic wire. This premise was soon discounted as the finished synthetic rod approached the physical and welding characteris-

tics of drawn steel. A.c.-d.c. and straight d.c. fluxes of the lime or titanium dioxide type were tried, with results indicating that the same type of fluxes used on drawn wire could be used on synthetic wire.

Thorough mixing of the base wire with the cladding during the actual welding has been questioned repeatedly, but constant checking of chemical analysis of various weld deposits and metallographic studies of weld metal has proved that thorough mixing is accomplished resulting in a quality equal to the deposit made by drawn stainless steel welding rod.

Close quality control of powder metal analysis, particle size, mixing and formulating, and extruding pressures are necessary to enable one to produce synthetic wire which will give consistent weld deposits. This extra cost of quality control is offset by the relatively low cost of producing the standard stainless steel grades of welding wire. The finished cost of synthetic welding rod core wire in sizes ranging from 1/4 to 5/32 in. varies from 2/3 to 3/4 of the cost of mill rolled and drawn wire. This is wire completely processed, cut to length and ready for flux coating.

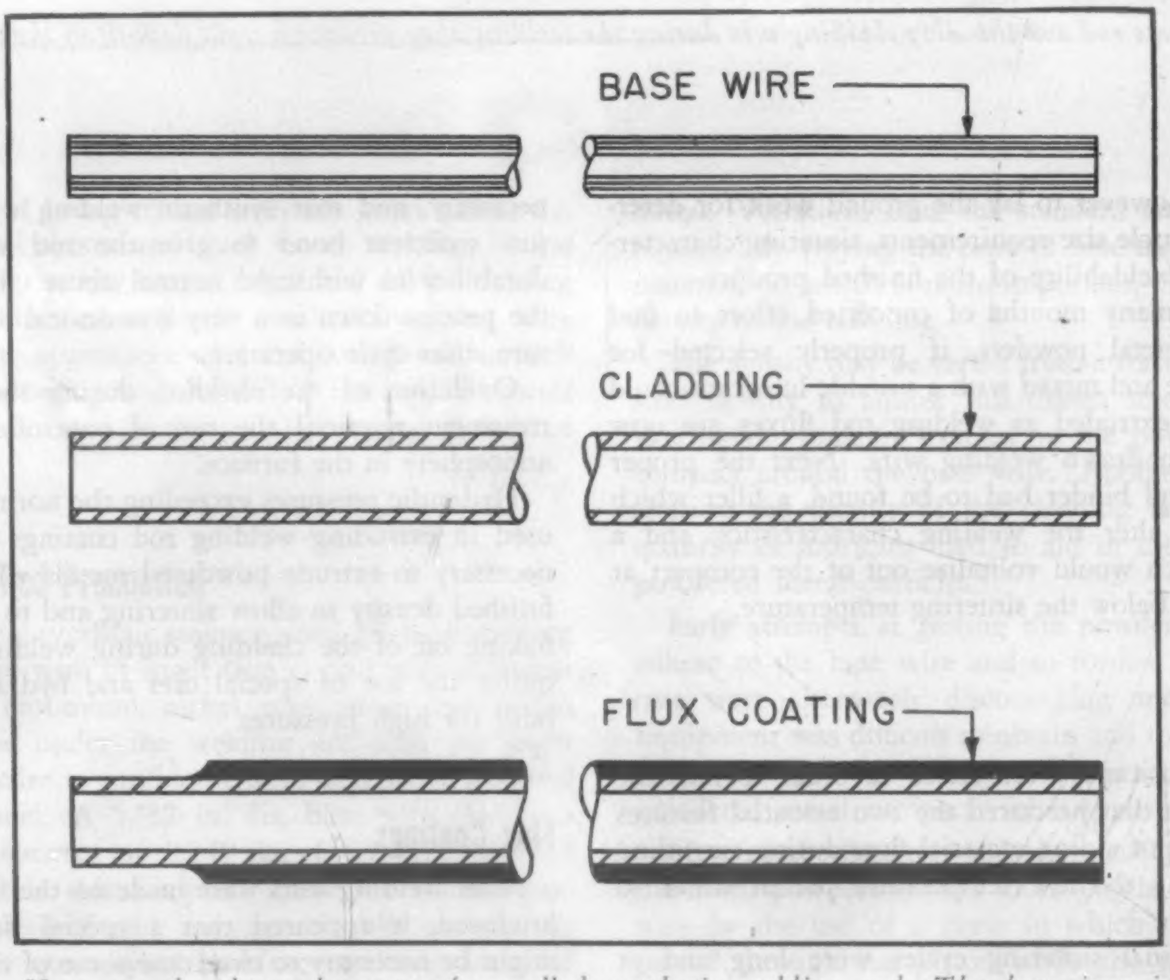
Tolerance on finished diameters can be maintained to plus or minus 0.002 in. depending upon the shop practice for replacement of worn coating dies. The base wire is, of course, cut to length before the cladding is extruded on the wire and this controls the length tolerance of the finished rod.

Prospective Applications

Much thought has been given lately to special alloys for strength at high temperature and such other qualities as demanded for use on turbosuper-chargers, rockets, jet propulsion, etc., and since the synthetic welding wire is quickly, cheaply and readily altered as to analysis the process herein outlined will have its place in producing welding rod and sintered powdered metal products for those exacting requirements.

One phase of the development of particular significance is the experience and knowledge gained in extruding powdered metal compacts with sufficient density to allow sintering after extruding. It is felt that this feature, plus the ability to clad basic metal parts with alloys, will lead the way to many new applications for extruding metal powders other than the welding electrode field.

Research engineers at Associated are continuing to explore the field of "die casting" powdered metals in order to eventually enable us to apply injection molding methods as applied to complex molds to form sintered powdered metal products.



Here are the three elements of so-called synthetic welding rod. The bare iron is covered with the alloying material and finally coated with flux. The cladding and coating are applied by similar methods.

MATERIALS & METHODS MANUAL

15

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Impact Extrusions

by HERBERT CHASE

Collapsible tubes have long been produced by the impact extrusion method, but recent applications of impact extrusions to other types of products point the way to their greater use. Outstanding among the special characteristics of products of this type are special ribs, bosses, flanges and tapers that can be provided without secondary operations. Although most impact extrusions have been used for containers or housings of various kinds, experiments have been made with their use as structural shapes on some parts produced by die casting and stamping.

Contents

Materials & Methods, May 1946

(Published Since 1929 as Metals and Alloys)

These parts illustrate types of ends which can be provided on impact extrusions.

Introduction

Impact extrusions are the products that result from striking slugs of metal placed one at a time in a die with a punch in such a way that a part of the metal is extruded through the opening between the die and the punch. Products thus made always have a cupped shape as they come from the die.

Applications include a large variety of cup-shaped parts and tubular elements, many of these being produced as substitutes for or in competition with substantially equivalent products drawn from sheet steel. Many extruded parts cannot be duplicated by drawing, however, partly because the base of the extrusion is often much thicker (or sometimes thinner) than the walls and frequently includes bosses and extensions not feasible as integral parts of drawn products.

In addition to collapsible tubes which are said to constitute some 95% of the total present output of impact extrusion presses, products made by this form of extrusion include: cases for dry cells; cans for vibrators and for condensors, both electrolytic and foil types; transformer and radio tube shields; cylinders for pumps, door checks and grease guns; cans for ignition coils; flashlight and cartridge cases; textile sleeves and bobbins; electric heater shells; tubular anodes; fire extinguisher and refrigerator parts and many other elements of cup-shape or tubular form. At least one aircraft manufacturer produced during the war some flanged and unflanged elements for use as structural elements in aircraft.

As shown in the foregoing list, the electrical and electronic industries are the largest consumers of impact extrusions aside from those using collapsible tubes as containers. It appears likely that other uses will be extended, however, as the utility of impact extruded products become more generally known.

The bottom of the extruded cup usually is thicker than the side walls and is, in reality, a forging. Side walls are commonly of uniform thickness, but can have longitudinal beads or can be fluted either internally or externally and can have a length many times the diameter of the base.

In one type of impact extrusion, the base includes a flange which can have a diameter two or more times that of the extruded portion. In others, a flange is produced by a secondary heading or upsetting operation.

Many secondary operations are performed on impact extrusions. They are usually trimmed at the outer end of the extruded portion and sometimes a projection on the base requires trimming to length. In certain forms the base is cut off, leaving only the extruded tube. The base can be pierced, drilled, tapped, threaded, or otherwise machined. Circumferential beads are often rolled in side walls and the walls can be pierced, notched, slotted, serrated, given a stepped diameter, spun over, or machined in other ways.

Materials Used

Only soft and ductile metals are suited for impact extrusions, partly because the pressures required for harder and less ductile materials becomes prohibitive. At present the materials used, in order of commercial importance are: Lead, aluminum, zinc and tin. Copper, magnesium and silver are among other soft metals that can be impact extruded, but demand for these is slight.

In general, metals that are substantially pure are most readily extruded, and with the exception of lead and zinc metals that are as nearly pure as can be produced commercially at a satisfactory price are used for most extruded products. Although pure lead can be extruded readily, the resulting product, especially when it has very thin walls, is too soft to be handled without distortion. For this reason, lead for extrusion is commonly alloyed with about 3% of antimony to give the extruded product adequate stiffness. When antimony has been scarce, other stiffening metals (including 0.5% silver) have been used in its place.

Although lead has high resistance to some types of corrosion, it is not immune to chemical attack by some materials for which lead alloy tubes serve as containers. For this reason, the tubes are commonly lacquered or are given some protective finish, some being tin clad, as indicated below.

Tin is readily extruded and before the war was used in pure form for the manufacture of collapsible tubes, despite its rather high cost per pound. Tin has a brighter color than lead, is quite resistant to tarnishing and is highly resistant to corrosion. All these are desirable qualities in collapsible tubes. Pure tin, though much stiffer than lead, is not stiff enough for some extruded tubes and has often been alloyed with 0.5 to 1.0% copper or with small amounts of zinc or bismuth to increase stiffness.

Shortages of tin during and since the war have restricted its use in pure or tin-rich alloys to only a few extrusion applications, chiefly for small containers for drugs or medicinals that cannot be packed safely in other containers. Tin is permitted, however, for cladding of lead for making extrusion slugs for some purposes, provided that the total tin does not exceed 3% of the slug's weight. About 95% of all collapsible tubes are now made either from lead-antimony alloy or from this alloy in tin-clad form. The remaining 5% is nearly all extruded from pure aluminum slugs.

Although the lead and tin extrusions mentioned above serve well for collapsible tubes, they lack in strength, hardness, and stiffness for most impact extrusions classed as "shells" (not to be confused with shells such as are used for ammunition). For this and other reasons, either aluminum or zinc, in pure or alloyed form, serves for making most impact extruded shells and open end tubes—the latter being shells from which the closed end has been cut.

Where low weight or some other special property of aluminum or of its alloys are not essential requirements, either zinc or aluminum can be chosen. Under current market conditions, costs per extruded piece are about on a par. Aluminum and its alloys have some advantage in initial appearance and sometimes in strength over the zinc extrusion but are not so easily soldered or plated. Zinc is required, of course, for dry cell cases, and, although these are frequently drawn, some shapes and sizes are extruded.

Aluminum impact extrusions when produced for use as rigid shells, are made from 2S alloy (99+% Al), while collapsible tubes are made of aluminum of 99.7% purity. When extruded, 2S becomes approximately full hard. It is easier to extrude 2S than aluminum alloys and it has ample strength and hardness for most shell work. When used for collapsible tubes, the extrusions are so stiff that they require annealing (an extra operation not required on lead or tin tubes).

Aluminum alloys that can be cold-extruded from soft slugs include A51S, 53S and 61S. All of these work harden rapidly and are more difficult to extrude than 2S but yield a stronger material essential for some applications. For the stronger alloys, such as 17S, extrusion methods are still under development; heating to 600-700 F may or may not be required, depending on the alloy, the thickness and general requirements of the part.

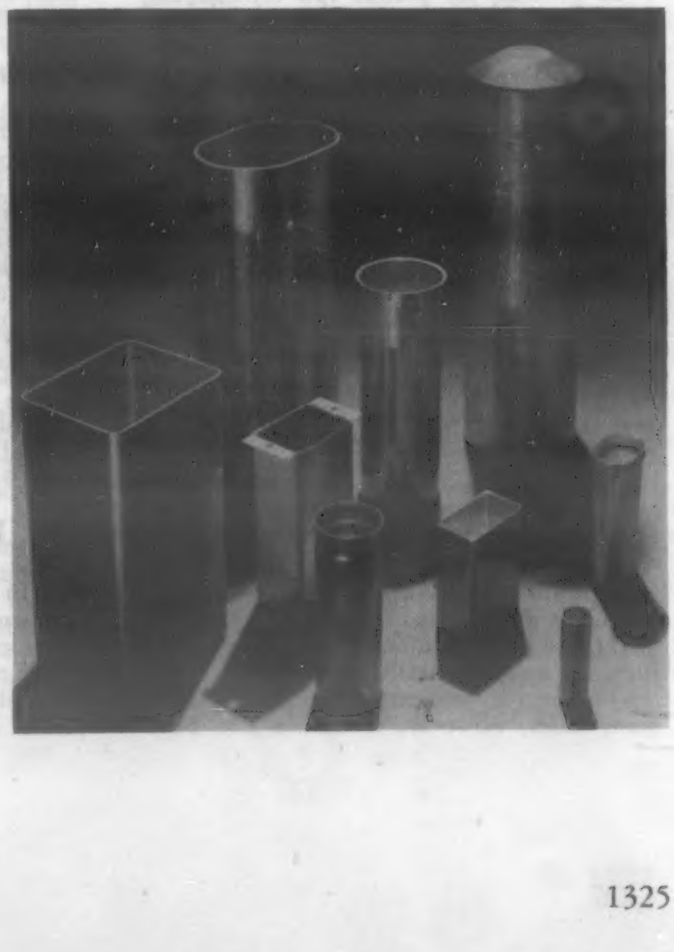
Because of the higher physical properties of aluminum and its alloys, more tool wear may be expected than with lead or tin. Impact extrusions made of aluminum, however, are much stronger than those made of lead or tin. Although many types of products are packed in bare aluminum, collapsible tubes made from this metal may be coated with an interior lacquer when the nature of the content makes this necessary. Certain products, which would otherwise have a tendency to attack aluminum, may be rendered inert by adding small percentages of inhibitors. Rigid aluminum containers can also be coated on the inside; they may be decorated on the outside with enamel and ink. The Alumilite process, which produces a hard oxide surface on articles made of aluminum and its alloys, can be varied to produce attractive finishes, both plain and colored.

Only one zinc alloy is in common use for impact extrusions and its nominal composition is: lead, 0.20; iron, 0.01; and cadmium, 0.07%; remainder zinc. This is a rather soft and ductile material but has ample strength, hardness and stiffness for most shell applications. Slugs are heated to about 300 F before extrusion. The extruded product is bright but is subject to tarnishing which results in darkening unless a protective coating is applied.

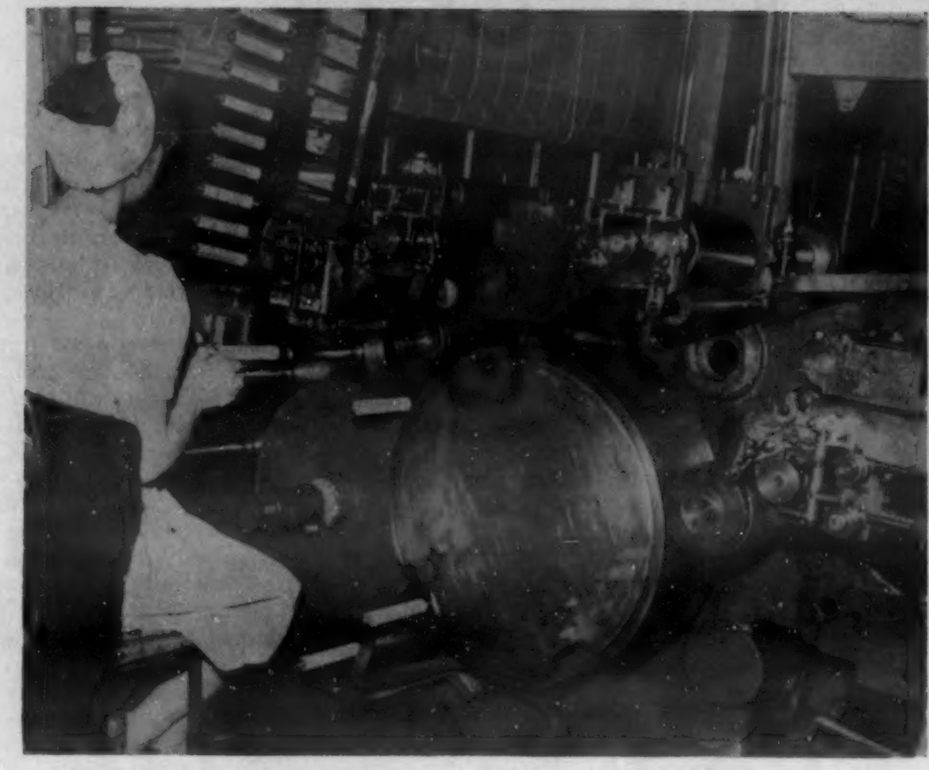
Zinc is quite active chemically and forms white oxide if exposed to moisture. This is one reason why zinc is not commonly used for collapsible tubes, but it is extensively applied for the impact extrusion of shells, especially for those employed in electrical and electronic applications. Many shells are made into open-end tubes. Ease of soldering and plating are assets which influence many applications.

Considerable impact extruding of pure copper has been done. Among the products that have been made are short open tubes for honeycomb automobile radiator cores but less expensive types of cores have largely, if not fully, supplanted this type. Other impact extrusions of copper are of minor commercial importance and are rarely offered by commercial makers of impact extrusions.

At least one aircraft company has experimented with impact extrusion of magnesium slugs at a temperature of 700 to 800 F but the process has not gained importance.



Impact extrusions include collapsible tubes and rigid parts for many industries, but have found greatest use in the electrical and electronic fields.



On machines such as this collapsible tubes are automatically lithographed. After leaving the machine the tubes pass through drying ovens.

Methods of Production

For rapidity and economy in production, crank-type or equivalent positive mechanical (as opposed to hydraulic) presses are used. As the pressures required are high, the presses have heavy frames and flywheels. For some aluminum extrusions, pressures approaching 200,000 psi. are said to have been attained. Less pressure is required for softer and more ductile metals. The required pressure is influenced by the shape of the punch and die and by the thickness of the extruded wall.

In general, the presses run continuously at a fairly high speed, especially when equipped (as is common in long-run work) with automatic feeding and stripping or ejector devices.

For the production of collapsible tubes, the presses not only run automatically but are equipped with attachments for ejecting the tubes onto a conveyor which handles the tube through trimming, threading and painting operations, the latter sometimes including interior as well as exterior coating. As aluminum work-hardens in extrusion, collapsible tubes made from aluminum are annealed after forming.

After the base coat of finish is applied, it is baked and the tubes are then returned to machines which apply printing and lithographing inks and cover these with a clear protective coat which is also baked before the tubes are packed in cartons for delivery.

For "shells" (as impact extruded products other than collapsible tubes are termed) quantities are commonly lower and, as a rule, no applied finish is required, hence less automatic equipment is needed. In many cases, however, trimming and bead rolling are done on automatic or semi-automatic equipment and other operations can be similarly performed.

All production of impact extrusions requires a die and a punch. In general, the die block and punch holder are more or less standard items. All that is required for making most ordinary extrusions, beyond the standard elements, are a die ring and a punch tip each being made to fit its respective holder. If special bosses, either interior or exterior are required on the base of the extrusion, the punch tip or die or both must have corresponding recesses.

Circular Slugs

In all but exceptional cases, the slug to be extruded is blanked in a press to make a reasonably close fit in the die. All except a very small proportion of slugs are circular and the parts to be made from them have only circular sections. This greatly simplifies the manufacture of the punch and die parts and makes them quite moderate in cost.

Although it is feasible to produce by impact extrusion parts having square, oblong, elliptical, or other non-circular section and demands for some of these are increasing, tooling costs are greatly increased. Square and oblong sections must have well rounded corners.

The Punch

The punch is always smaller than the hole in the die cavity in which it is centered. The annulus between the die and the punch provides the opening through which much of the metal in the slug is extruded to form the side walls of the extrusion. As the punch is forced into the metal the latter is forced to squirt (usually upward) around the punch, forming the side wall in a small fraction of a second, even though the wall is several inches in length.

In general, the slug is made a fairly close fit in the die but the impact of the punch forces the metal to completely fill all die recesses, including any holes for bosses or extensions, before the extruded wall is formed. As the extrusion proceeds, there is further flow of metal between the die and the punch. As the latter approaches the end of its stroke, it may come fairly close to the bottom of the die recess but usually not closer than 0.030 in. as at that point friction between die and punch end becomes excessive and the punch is arrested. Proper shaping of the die and punch end help to reduce the friction and to lower the maximum pressure required to complete the extrusion.

Since the impact of the punch and the friction are converted into heat, the extruded metal is heated and much work is done on it. Extremely heavy pressure is required to cause the rapid flow, and if the metal is one that work-hardens, more pressure is required as the hardening proceeds. The extrusion is much harder than the slug. In general, the slug does not require preheating but, for some metals, the slug must be preheated to yield satisfactory extrusion or to be extruded at all.

Only the tip of the punch has the size of the inside diameter extruded, the shank being given some clearance to facilitate stripping. In general, the extrusion clings to the punch and must be stripped from it but, especially for shells, the extrusion may stick in the die and require a push-out or

ejector pin, usually arranged for automatic actuation.

Collapsible tubes commonly have a wall thickness of only 0.004 in. and, although walls as thin as 0.003 in. have been produced, even in aluminum, there are few calls for walls so thin. In stripping a thin wall extrusion, the outer end is somewhat deformed. For this reason, the wall is made long enough to trim off the deformed portion. This and other scrap is slight and can be recovered by remelting, with only slight net loss, as a rule.

Preliminary and Supplementary Operations

Before extrusion, it is necessary to prepare suitable slugs. These are usually produced with gang punches from strip stock of the required thickness. Portions of the strip remaining as flash are remelted. In general, the slug is a solid disc, but when the extrusion is to have a flange and is to be produced in a Hooker process die, the slug has a hole pierced at its center to fit the extrusion punch.

When the extrusion must have an unusually thick end or walls that are thick and quite long, it may not be feasible to punch the slug from sheet stock. This is true of slugs that must have a length equal to or longer than their diameter. Such slugs are cut from bar stock.

The height (thickness) of the slug determines the length of the extrusion and usually is controlled accordingly but where slugs are stocked in standard thicknesses or the precise thickness needed is not available, a slug slightly thicker than needed is often used. The extra length of extruded portion is trimmed off subsequently. In all cases, however, some allowance for necessary trimming is made, as the extrusion does not have a square end as produced.

Nearly all makers of extrusions roll their own strip stock, at least in lead or tin, and several make lead strips on which tin is "clad" or laminated to one or both sides by the rolling process. The rolling as well as the extrusion leaves a thin layer of tin on one or both surfaces of the extruded product, improving its appearance and giving the surface the corrosion resistance of a tin coating.

After slugs are cut, they are sometimes tumbled in a lubricant. This removes burrs that might interfere with insertion of the slug in the die, in which the slug should have minimum clearance. The coating of lubricant left on the slug facilitates extrusion and helps to prolong the life of the die and of the punch tip.

Following extrusion, the end of the extruded portion is trimmed, usually on a mandrel which rotates with the work. Either a rotary or fixed knife that produces a shearing action can be used on thin-walled parts. For thicker walls, a cutting tool similar to a cut-off tool can be applied. If a tube having both ends open is required, the bottom can be cut off at the same time that the open end is trimmed.

Collapsible tubes, as well as some other extrusions, have a central projection in which the punch tip produces a blind hole. To open the hole, if this is required, the end of the projection usually is cut off at the same time that the opposite end is trimmed. The outside diameter is often threaded, usually with a cutting tool, but, especially on aluminum extrusions, a rolled thread may be produced.

While an extrusion is being rotated on a mandrel, other operations, such as rolling a bead, rolling a stepped diameter, knurling some portion or spinning the open end can be done. Still other operations, such as upsetting a flange around the thick end, drilling, piercing or tapping this end or performing other machine work on the end often are done. Side walls can be pierced, slotted, notched at the outer end, threaded, if they are thick enough, or can be machined in other ways, much as with drawn products.

Most extrusions are not heat-treated but, with aluminum, which is work-hardened in the extrusion process, heat-treatment is often applied. Pure aluminum tubes that are to be made collapsible (for use as containers) are annealed after extrusion. Aluminum alloys can be given heat-treatments identical with those for the same alloys in other wrought forms.

Tooling Practice and Costs

Dies for impact extrusion are commonly made from hardened alloy steel. The punch is so made that only the tip need be changed and the die is made so that only a ring or disc is changed for turning out products of slightly different diameters and bottom shapes. The length of the extrusion can be altered by merely changing the thickness of slug without changing the die.

The shape of the inside of the bottom and the inside diameter of the extrusion are controlled by the shape and size of the punch tip. The tip is normally made with the lower end flat (though sometimes roughened) except for a bevel usually at an angle of about 15-deg. with the horizontal. Above the bevel is a narrow cylindrical band, only a few thousandths of an inch in width and highly polished. Above the band, the tip is rounded slightly and then beveled back to the diameter of the shank, which is commonly about 0.004 in. smaller than the band diameter that controls the inside diameter of the extrusion.

Other punches are made flat, except for a radius at the edge and some have an included angle of 120-deg. which is said to require minimum pressure on the punch. Still other punches are given whatever shape may be needed to form the bottom, with or without bosses, and to force the metal to fill the die recess. Often the punch has a central projection to form a blind hole in the bottom of the extrusion.

Dies have a recess which is given a slight outward taper, say 0.002-in. on a side, for a depth approximating that of the slug, especially if the extrusion is to cling to the punch. The shape of the bottom of the die depends upon the shape of the outside of the bottom to be formed but there is always at least a small radius where the bottom and side wall of the cavity join, as this radius helps to direct the flow of the metal upward. Often, the bottom of the die cavity is so shaped that it is parallel to the end of the punch, as this yields a bottom of uniform thickness. Die bottoms often have one or more holes into which metal is forced to form external bosses or projections.

It is the annulus between the punch and the side wall of the die that determines the thickness of the side wall of the extrusion, because it is through this annulus that the metal is extruded. The side wall will have uniform thickness unless the punch is forced off center, provided, of course, that the punch and die are properly aligned in making the setup.

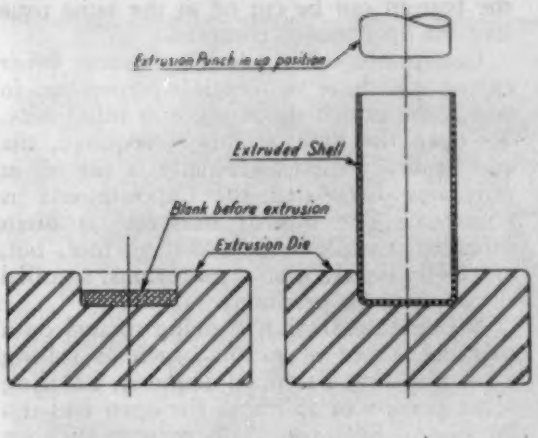
Slugs usually are made to fit the die recess quite closely because, if they are slightly smaller, they may slip sidewise and deflect the punch enough to produce eccentricity, so that walls will not be of uniform thickness. In efforts to prevent transverse motion of undersize slugs, the end of the punch or even the bottom of the die (but not both) are sometimes roughened, say in a grid or spiral pattern that is duplicated on the mating surface of the extrusion. Either the end of the punch or the die bottom must be smooth or even polished, however, to facilitate flow of the metal toward the extrusion annulus.

Although small bosses that are eccentric and not symmetrical can be produced either on the inside or outside of the bottom of the extrusion, this arrangement is not advocated, as it tends to throw the punch out of line. Similarly, if there are to be longitudinal beads or bands on the inside or outside of the extruded wall, these must be symmetrically arranged. Otherwise, the punch will be deflected and walls non-uniform in thickness will result.

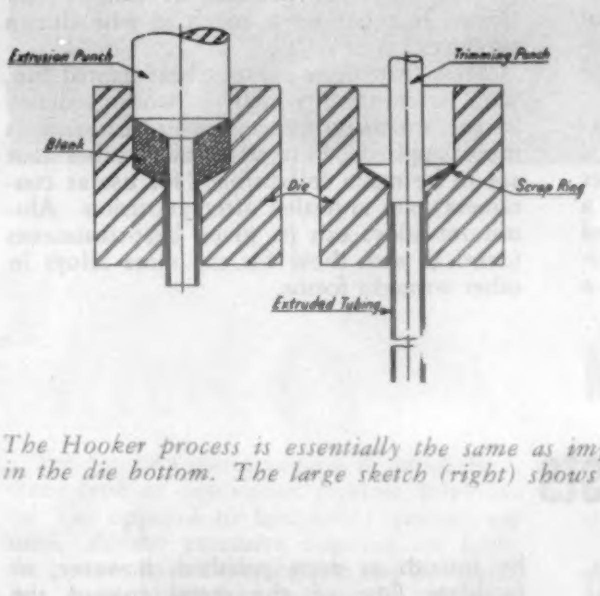
To produce interior beads, the punch must be grooved and for exterior ones the die must have notches to shape the beads. It is possible to produce fluted walls but their production increases die cost as does any departure from a true circular section.

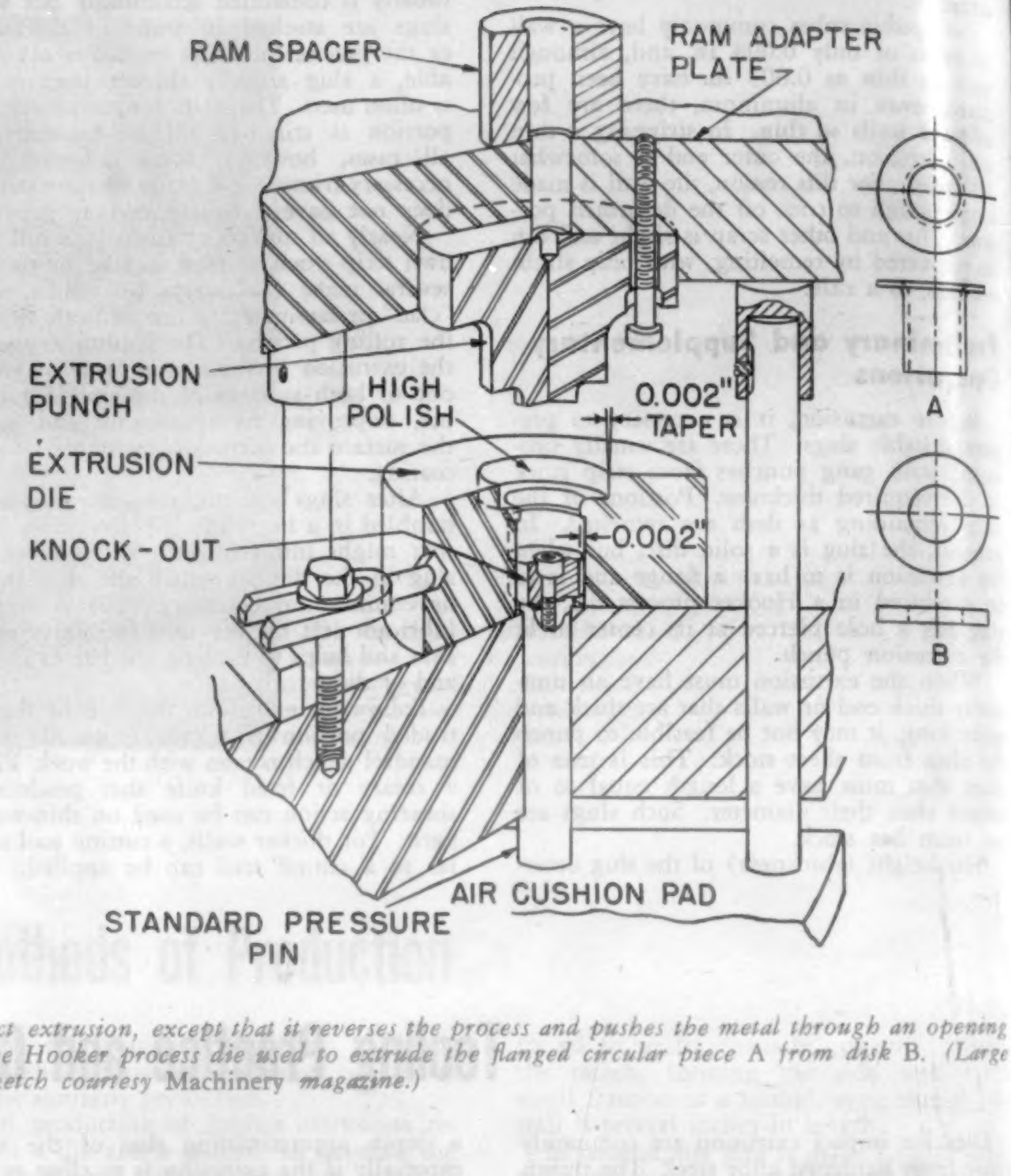
Extrusions having square or oblong sections sometimes are preferred, especially for certain electrical applications, but their production involves greatly higher die costs because it requires more time and more skill to produce the corresponding dies and punches, the surfaces of which must be ground.

Some production of impact extrusions has been done with dies in which carbide punch tips and die rings have been used. Although wear can be minimized and sizes held within close limits with carbide dies, their life has not been long, the author is advised, because cracking occurs. Means for overcoming this fault may yet be found.



In the impact extrusion process the punch strikes the blank and squirts metal through the annular opening between punch and die.





The Hooker process is essentially the same as impact extrusion, except that it reverses the process and pushes the metal through an opening in the die bottom. The large sketch (right) shows the Hooker process die used to extrude the flanged circular piece A from disk B. (Large sketch courtesy Machinery *magazine.)*

The above sketches show a Hooker process die for producing a flanged extrusion. This form of die uses a stepped punch the smaller diameter of which passes through a hole pierced in the center of the slug before the larger diameter strikes the slug and extrudes a part of it through the annulus between the small diameter punch and the die hole. In this case, the extruded wall is forced downward through the die hole, the flange being formed by the portion of the slug that remains in the die below the punch band. After the punch is raised, a knockout forces the extrusion out of the die.

Plants that specialize in producing extrusions generally have standard holders for die rings and punch shanks so that, as a rule, for conventional dies, only the ring and tip need be made and charged to the customer. As these parts are small and good facilities for making them usually are available, tooling costs are usually quite low, often below $50. This gives the extrusion an advantage over drawn products for which dies are likely to cost much more, especially if the product is deep and requires several draws. Dies for non-circular extrusions cost much more than those for those having a circular section and, when bosses or non-standard projections are needed, costs are somewhat increased.

Some companies have established standards for the common types of collapsible tube ends and some have standards for shells and for open end tubes. Certain of these standards are given in accompanying tables. Where standard sizes and shapes are available, little or no tooling charge is made. At least one company has standards for zinc shells and open end tubes, some of which are beaded circumferentially, the standards including the shape, size, and location of the beads, base piercing, side and base stampings (markings) as well as of the extrusion itself.

Production Speeds

Although the production speed on extrusions up to about 1½ dia. varies from about 35 to nearly 70 pieces a min., the average is close to 60 per min. or one a second. Of this second, about 20% is for forming the extrusion itself, even when an extrusion 6- to 7-in. long is made. This is considered about the maximum rate of flow economically feasible in impact extrusion work.

In general, about 80% of the cycle time is consumed in loading the slug and stripping the part from the punch or ejecting it from the die. A blast of air is commonly used to throw the extrusion clear of the die and into a chute down which it usually falls onto a conveyor that carries it to a trimming station. Other operations, such as threading or beading, are often done while the extrusion is being rotated.

For long-run work, the secondary operations, including the application of a finish, when one is required, are commonly arranged to keep step with the production of the extrusion itself. This necessitates the use of conveyors and automatic equipment.

In most impact extrusion, the presses are arranged for automatic feed and ejection and the presses run automatically with relatively little attention, once a setup has been made. This makes for low labor cost and permits attainment of the rates mentioned above. Although hand feeding can be done, it would be difficult to maintain the high production rate attained with automatic setups and runs commonly must be fairly long to warrant these setups and attain highest economy.

Although secondary operations usually can be done also on fully automatic equipment, hand feeding and control of the machines may be necessary or more economical, especially for the shorter runs that are more common when shells rather than collapsible tubes, are produced. Many secondary operations more or less parallel those required on competitive products, especially those drawn from sheet stock.

Dimensions and Dimensional Tolerances

Wall thickness on collapsible tubes having the usual wall thickness of 0.004-in. is commonly held within ±0.0002 in. For cylindrical shells extruded from zinc and having walls 0.014-in. or thicker, the usual tolerance on wall thickness is ±0.002 in. The corresponding tolerances for aluminum are ±0.003 in.

Inside diameter on both zinc and aluminum shells can be held within +0.000 -0.006 in. and outside diameters within ±0.003 to ±0.005 in. Bottom thickness can be held within about the same limits. For these dimensions, the lower limits apply to extrusions of about ½ in. o.d. and the larger ones to extrusions of about 1½ in. dia.

Efforts are commonly made to keep the punch truly concentric with the die so that walls of uniform thickness are held but the above variations in wall thickness tolerances are indicative of the eccentricity that is permitted and sometimes occurs.

Since extrusions are always trimmed, either at one or at both ends, the overall length is controlled by the trimming operation. It is usual to hold length within ±0.015 in. of that specified unless, for some particular reason, closer limits are essential.

Although walls thinner than 0.004 in. can be produced in the softer extrudable metals used for collapsible tubes, 0.004 in. is the thickness commonly specified. For products classed as shells, the following approximate minimum wall thicknesses are given as guides, although where process of adequate size are available, somewhat thinner walls may be producible.

Minimum Wall Thickness for Aluminum Shell Extrusions

Outside diameter	2S in.	A 51S, 53S and 61S alloys — in.
¾	0.010	0.094
1	0.015	0.094
1½	0.020	0.094
2	0.020	0.125 to 0.187
2½	0.020	0.125 to 0.187
3	0.025	0.125 to 0.187
3½	0.025	0.219 to 0.281
4	0.030	0.219 to 0.281
4½	0.040	0.219 to 0.281
5	0.075	0.219 to 0.281

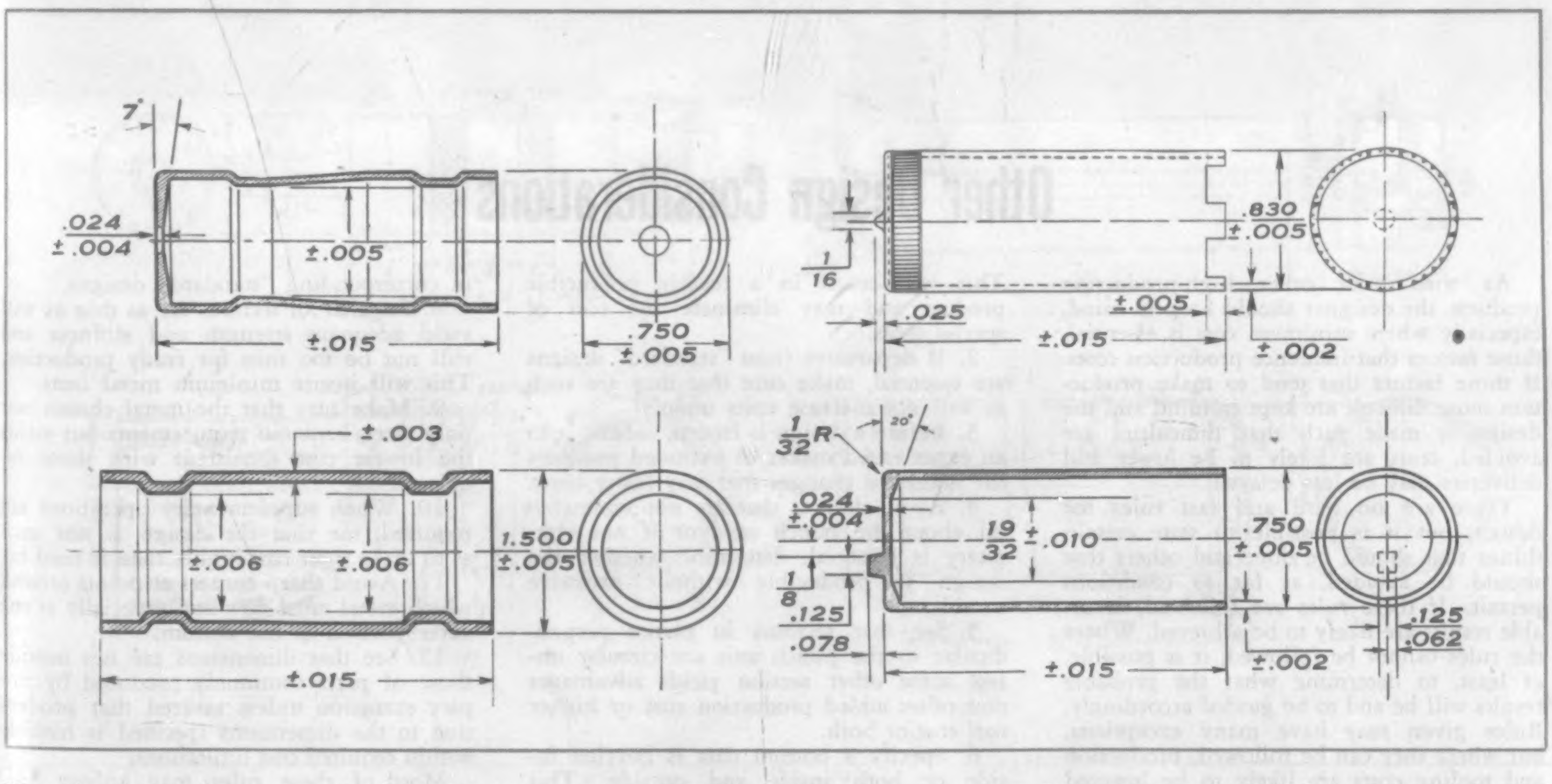
Equally thin walls can be extruded in zinc but diameters in excess of 1½ in. are not commonly produced. There is no maximum limit on wall thickness except that imposed by the volume of metal in the slug, but there is little demand for thick wall extrusions.

Internal diameters are controlled by the diameter of the punch which forms them and have little or no taper but outer diameters sometimes have a slight taper of, in the case of zinc extrusions, between 0.001 to 0.002 in. per in. of length.

Minimum bottom thickness usually approximates 0.030 in. but is always greater than the thickness of walls. This is partly because, as the punch advances and the bottom becomes thinner, friction between the metal, which is flowing, and the die wall and end of the punch increases rapidly and the punch is arrested. The only limit on the maximum thickness of bottom is the thickness of the slug or the volume of metal remaining to form the bottom. Tolerances on bottom thickness commonly range from ±0.003 to ±0.007 in., increasing slowly as diameter increases.

The maximum length of extrusion that can be produced depends, first, upon the volume of metal in the slug and, second, (in the case of the usual type of die) upon the length of punch which it is feasible to use and, third, upon the maximum pressure required. The punch acts as a column which is heavily loaded, so the load may not exceed the column strength, as then the punch will be bent. Of course, the length of extrusion cannot exceed that which will clear the die and be ejected.

With dies of the Hooker type, where only a short punch is needed and it is not loaded in compression, any length of tube that can be removed from the press can be produced, theoretically, if the die will hold a slug of sufficient volume and the stroke and power of the press are adequate. The limiting length then approaches that of (non-impact) hydraulic presses such as are employed for extruding long bars, tubes, and shapes in a different branch of the metal working industry.



These four examples are typical of zinc impact extrusion as produced by one manufacturer. Top left *is a shell with pierced and beveled bottom one narrow bead and a long taper next to another bead.* Bottom left *is a tube with both ends open and radius bead rolled in near each end.* Top right *shows a shell with base flat inside, a central rib outside, dia. next to bottom knurled and open end notched.* Bottom right *illustrates a shell having an eccentric square projection on outside of bottom which is beveled inside.*

About 95% of the output of impact extrusion presses is in the form of collapsible tubes such as the familiar types shown here. Many of the caps used are also impact extruded.

Other Design Considerations

As with most other high-production products, the designer should keep in mind, especially where minimum cost is essential, those factors that influence production costs. If those factors that tend to make production more difficult are kept in mind and the design is made such that difficulties are avoided, costs are likely to be lower and deliveries may be less delayed.

There are no hard and fast rules for design, but it is possible to state certain things that should be done and others that should be avoided, as far as conditions permit. If these rules are followed, favorable results are likely to be achieved. Where the rules cannot be followed, it is possible, as least, to determine what the probable results will be and to be guided accordingly. Rules given may have many exceptions, but where they can be followed, production and tooling costs are likely to be lowered and favorable results achieved.

1. Where "standard" designs exist and meet essential requirements, adhere to them. This will result in a readily producible product and may eliminate the cost of special tools.
2. If departures from "standard" designs are essential, make sure that they are such as will not increase costs unduly.
3. Before a design is frozen, submit it to an experienced maker of extruded products for suggested changes that may lower costs.
4. Avoid designs that are not symmetrical about the punch axis, or if non-symmetry is essential, determine whether the design is producible without excessive trouble.
5. See that sections in planes perpendicular to the punch axis are circular unless some other section yields advantages that offset added production cost or higher tool cost or both.
6. Specify a bottom that is beveled inside or both inside and outside. This tends to help keep the punch centered and to reduce the pressure required.
7. Avoid dimensional limits that are closer than necessary or that are closer than in corresponding "standard" designs.
8. See that all sections are as thin as will yield adequate strength and stiffness and still not be too thin for ready production. This will insure minimum metal costs.
9. Make sure that the metal chosen not only meets *essential* requirements but yields the lowest cost consistent with these requirements.
10. When supplementary operations are required, see that the design is not such as to make their cost higher than it need be.
11. Avoid sharp corners at points around which metal must flow and especially at the outer portion of the bottom.
12. See that dimensions are not outside those of parts commonly produced by impact extrusion unless assured that production to the dimensions specified is feasible within required cost limitations.

Most of these rules may appear self-evident but if designs are checked against them it may be found that some which might be followed with profit have been overlooked.

Advantages and Limitations of Impact Extrusions

The chief advantages of extrusions include:

1. Rapidity of production on an automatic or semi-automatic basis so that labor per piece is small.
2. Availability in a considerable number of metals each of which has certain desirable properties.
3. Possession of the characteristics of wrought metal which is dense and free from porosity.
4. Availability in certain shapes and section thicknesses or combinations of these not available or not available at equal cost in other types of product.
5. Availability in forms that are made ready for use in a single fast operation, except for trimming.
6. Such secondary operations as are required are rapidly performed.
7. Scrap losses are low and such scrap as is produced is recoverable and often reused in the same plant.
8. Surfaces are remarkably smooth and require little or no preparation for applied finishes.
9. Ability to take a variety of finishes costing little for application.
10. Excellence of appearance.
11. Unusually low tooling cost for most forms.
12. One-piece seamless construction.
13. Availability within quite close dimensional limits and with comparatively slight variation from piece to piece.

Limitations include:

1. Shapes are confined to those involving a tube with or without a bottom.
2. Range of materials is much more limited than for most other comparable products and does not include ferrous materials.
3. Require specialized equipment and technic.
4. Slugs must be cut from sheet, strip, or bar stock which has undergone considerable processing and is not inexpensive.
5. Require some secondary operations not always needed on comparable products.
6. Certain size limitations not applying to other products are imposed.
7. Some physical and certain other properties are inferior to those attainable in similar products.

In comparing impact extrusions with competing products, both the advantages and limitations should be checked against those of the respective products considered. When, as is often the case, the balance of advantages is in favor of extrusions and they meet "must" requirements, the impact extrusion is the logical choice.

Where Extrusions Effect Economies

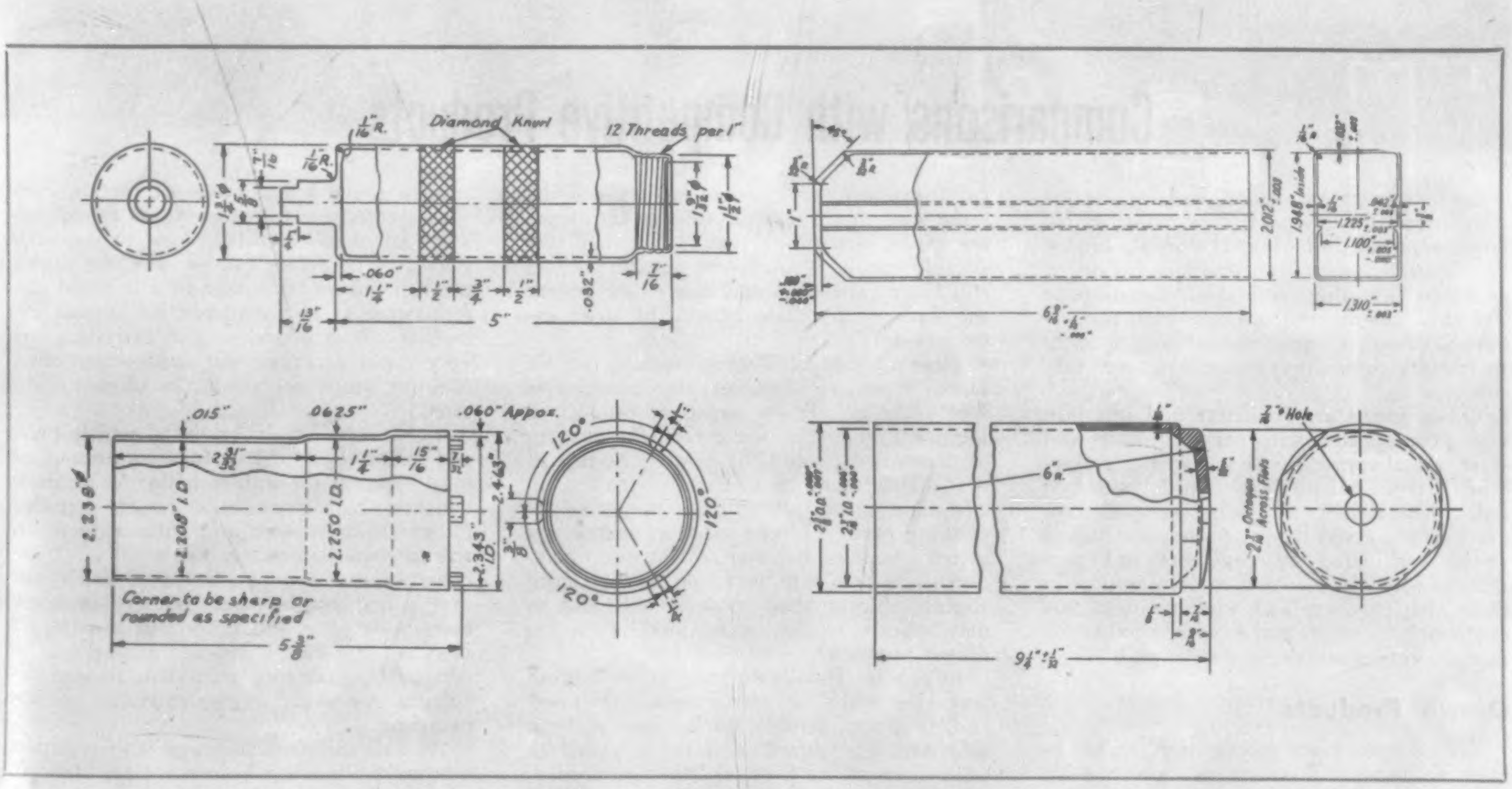
Application of impact extrusions is commonly limited either to those products which can be made by no other means or to those that are produced most economically in this form.

Impact extrusions should be considered when:

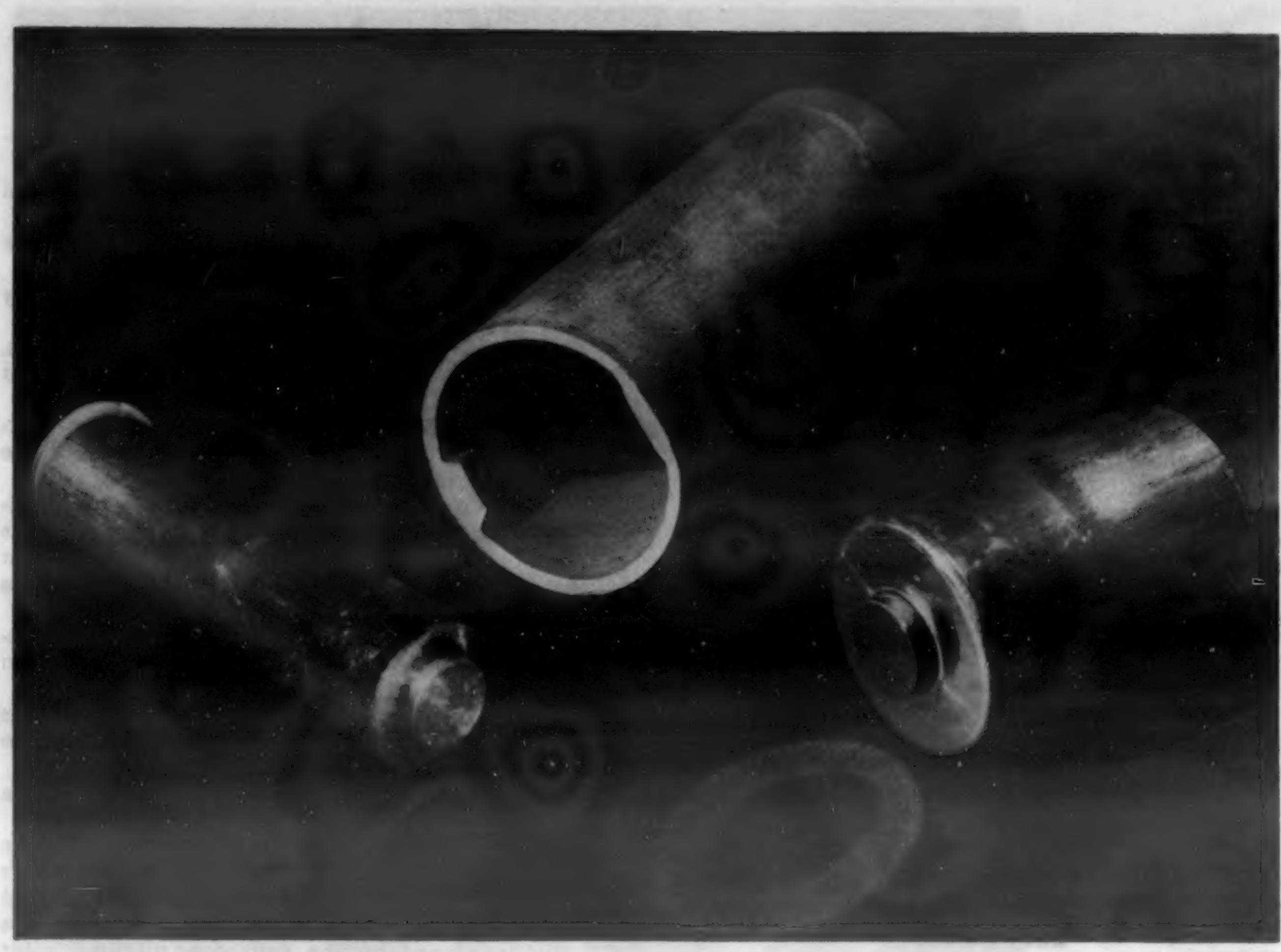
1. Length exceeds 1½ to 2 times the diameter.
2. When a bottom that is considerably thicker than side walls is required.
3. When the bottom must include bosses, projections, or recesses not readily formed from sheet stock in drawing.
4. Where shapes too difficult or too expensive to be drawn from sheet stock are required.
5. Where side walls must have longitudinal internal or external ribs or beads that are symmetrically arranged and that involve variations in section thickness around the circumference.
6. Where short open-end tubes are required in lengths that cannot be drawn with equal economy.
7. Where short tubes not producible as hydraulic extrusions or by drawing are needed.
8. Where a bottom extending into a flange is required.

Naturally, since impact extrusions are produced only from comparatively soft and ductile metals, they can be considered only when such materials (sometimes hardened by the extrusion process) meet requirements.

Reasons for some of these limitations appear under subsequent headings.



These typical aluminum impact extrusions were produced by the Aluminum Co. of America. Top left *is a cylinder having a steeped jug at the closed end with the opposite end rolled in and threaded.* Bottom left *illustrates an ignition coil can having a wall of varying thickness and two stepped diameters produced after extrusion. Notching was done in a secondary operation.* Top right: *This can has an oblong section and longitudinal internal ribs that form a track.* Bottom right: *A thick-wall grease gun cylinder with closed end octagonal in shape.*



Varying thicknesses of ends and diameters are provided on impact extrusions without difficulty.

Comparisons with Competitive Products

Some impact extrusions, such as collapsible tubes, for example, that constitute so large a proportion of total output, cannot be duplicated with comparable economy if at all, by any other method of manufacture. To this extent, the impact extrusion is beyond direct competition although other forms of containers sometimes are substituted.

Other forms are in direct and often in active competition with other products and it is not always easy to say with certainty which type of product affords the best balance of advantages. Some general comparisons are given below, as they are bound to be considered by engineers and purchasers who often face keen competition in their own products and who, to meet this competition, must make wise choices or face the consequences.

Drawn Products

Exceedingly keen competition exists in such nonferrous products as battery (dry cell) cases and other cup-like products many of which are drawn from sheet stock at costs believed to equal or to be lower than corresponding impact extrusions.

Drawn products are made from blanks cut from sheet or strip stock, in much the same way that slugs for impact extrusions are made, but thinner stock, that may cost slightly more, is used. Some competitors roll their own strip and can either remelt the flash or purchase blanks, as large extruders do.

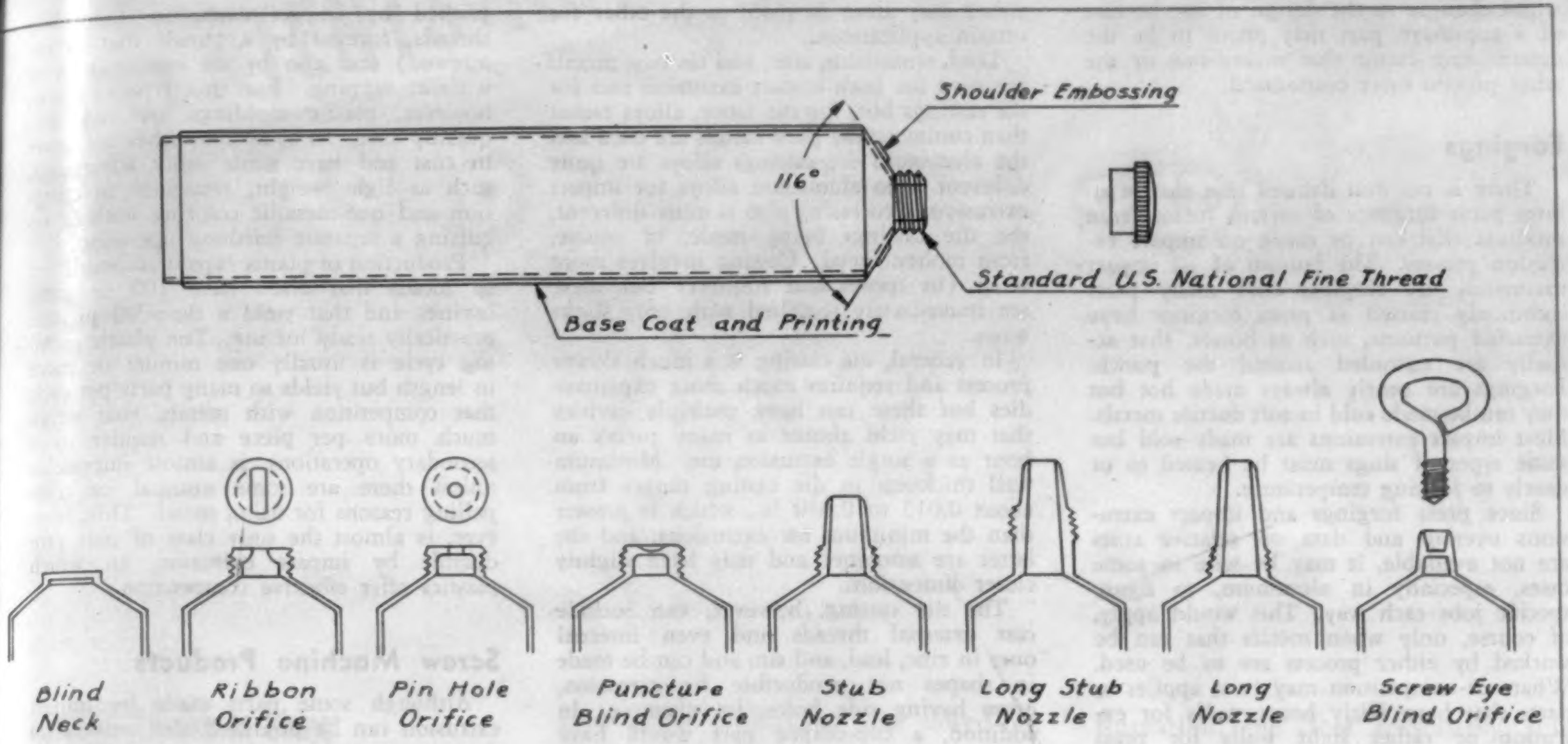
Drawn products, however, usually require more expensive dies, of the progressive type. The greater the depth of product in relation to diameter, the greater the number of draws needed and the greater the cost of dies. This tends to give the extrusion an advantage as it is produced in one stroke of the press and can be made as deep as six to ten times its diameter in this one operation. The extrusion, however, has a bottom slightly thicker than its side wall and so may require slightly more metal than the drawn product.

In general, the drawn product has bottom and side walls of about equal thickness and, if a considerably thicker bottom than side wall is required or if thick walled or solid lugs or long extensions are needed, the drawn product yields to the extrusion. When either can be used, secondary operations are about the same and can be done by similar means.

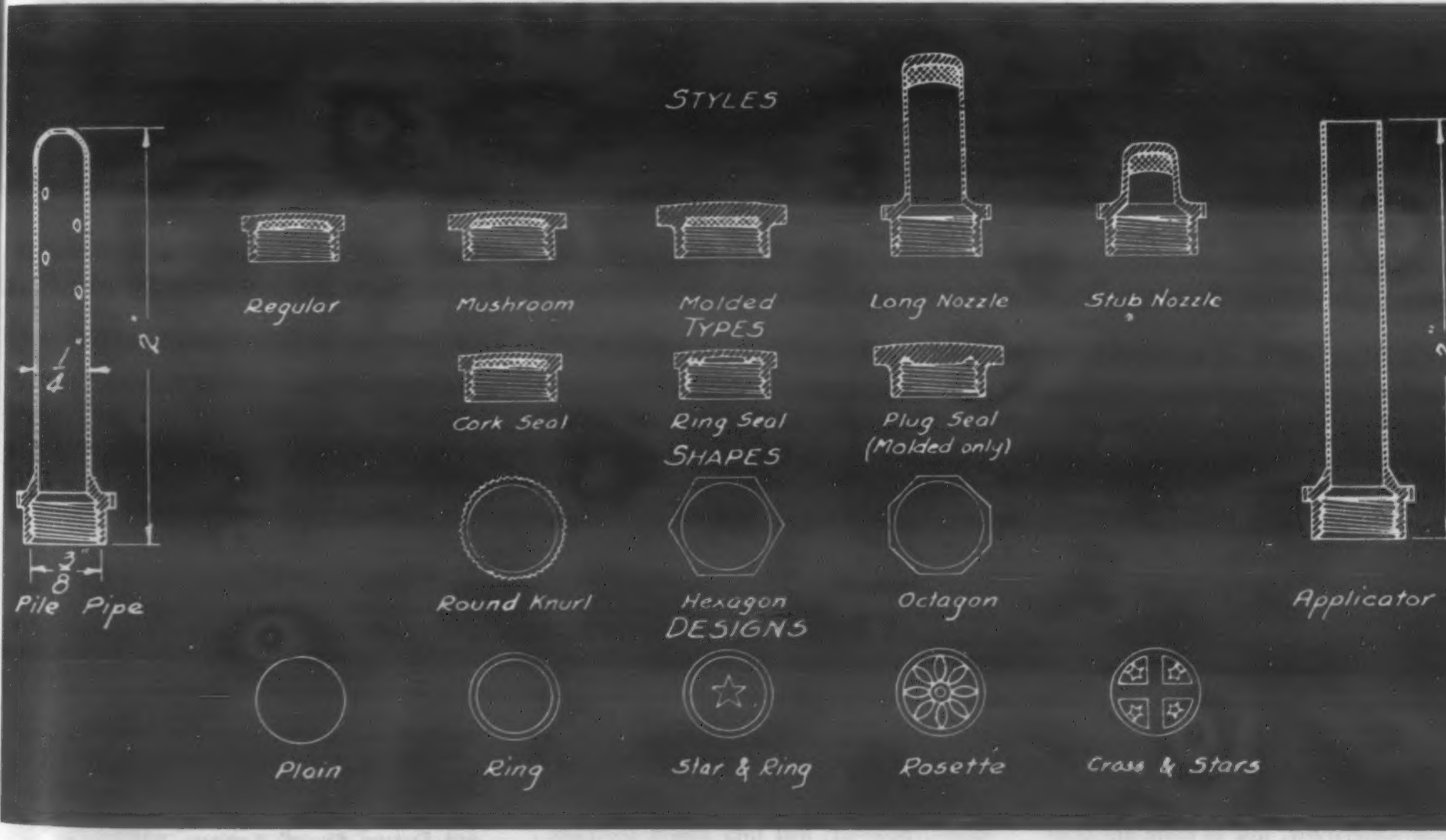
Drawn products can be made, of course, from a much wider range of metals, even when confined to nonferrous types, but some of these require annealing between draws. Where steel can be used, the drawn product has an advantage of a low-cost material that is not available for impact extrusion. Both drawing and extruding are very rapid processes but the former often requires more operations, as already indicated.

Tubes can be drawn in a punch press and can also be drawn (in continuous or long lengths) through suitable dies on draw benches. Nonferrous tubes can be extruded in hydraulic presses and then reduced in size or wall thickness or both in draw-bench operations. Such tubes, easily cut into short lengths, can compete in some cases with open end tubes that are impact extruded but this competition may not be of much significance until lengths and diameters not easily impact extruded are approached.

As wall thickness increases, above certain minimum, drawing becomes more difficult whereas the reverse is true in respect to impact extrusions. Here again, the balance is close and only a careful weighing of many factors for specific pieces is likely to determine which is the cheaper process. Often,



At top is shown a standard collapsible tube produced by impact extrusion. Below are standard shapes of special necks and orifices in aluminum.



A wide variety of caps for collapsible tubes is illustrated here. They, too, are produced by impact extrusion.

slight changes in the design of the bottom of a cup-shape part may prove to be the determining factor that makes one or the other process more economical.

Forgings

There is no well defined line that separates press forgings of certain forms from products that can be made on impact extrusion presses. The bottom of all impact extrusions are forgings and many parts commonly classed as press forgings have extended portions, such as bosses, that actually are extruded around the punch. Forgings are nearly always made hot but they can be made cold in soft ductile metals. Most impact extrusions are made cold but some types of slugs must be heated to or nearly to forging temperature.

Since press forgings and impact extrusions overlap and data on relative costs are not available, it may be wise in some cases, especially in aluminum, to figure specific jobs each way. This would apply, of course, only when metals that can be worked by either process are to be used. Whatever competition may exist applies to parts that have fairly heavy walls for extrusion or rather light walls for press forging.

One difference that can be mentioned is that forgings usually have confined recesses into which any extruded portion is forced whereas, in extrusions, the major extruded portion is not confined after being forced out of the opening between die and punch. There are of course many forgable alloys that are not suited for impact extrusion.

Die Castings

Although there may be little actual competition between impact extrusions and die castings, it is certain that many such extrusions can be duplicated in shape and dimensions by die casting. Extrusion, of course, yields a wrought product that is dense and free from porosity. As opposed to this, the die casting has a granular structure that is subject to some porosity. But, since neither part is subject, as a rule, to stresses approaching actual yield strength, either may serve in place of the other for certain applications.

Lead, aluminum, zinc, and tin base metals are used for both impact extrusion and for die castings but, for the latter, alloys rather than commercially pure metals are used and the aluminum die castings alloys are quite different from aluminum alloys for impact extrusion. Processing also is quite different, the die castings being made, of course, from molten metal. Casting involves more scrap (in sprues and runners) but these are immediately remelted with only slight waste.

In general, die casting is a much slower process and requires much more expensive dies but these can have multiple cavities that may yield almost as many pieces an hour as a single extrusion die. Minimum wall thickness in die casting ranges from about 0.015 to 0.030 in., which is greater than the minimum for extrusions, and the latter are smoother and may have slightly closer dimensions.

The die casting, however, can include cast external threads and even internal ones in zinc, lead, and tin, and can be made in shapes not producible by extrusion, often having side holes, for example. In addition, a cup-shaped part would have walls of fixed length and of almost any end contour (notched, for example), as cast, and so may require fewer secondary operations than the extrusion, especially if threads are involved. Much more draft is required on the die casting, however, but it too can have longitudinal ribs and bottom bosses or projections. In the die casting, these can be either concentric or eccentric without disadvantage.

It is probable, however, that, especially in shapes favorable for extrusion, costs will favor this type of part over one that is die cast. But where the extrusion requires such secondary operations as drilling, tapping, threading, flanging, or side holes, notching or external undercuts, the die casting may be lower in cost and afford shapes not available by extrusion without too many secondary operations.

Plastic Moldings

The production of flanged and threaded caps for collapsible tubes can be accomplished by impact extrusion (including threads, formed by a punch that is unscrewed) and also by die casting with or without tapping. For this type of parts, however, plastic moldings are now frequently used. In some cases, they are lower in cost and have some other advantages, such as light weight, resistance to corrosion and non-metallic coloring without requiring a separate finishing operation.

Production of plastic caps is accomplished in molds that often have 100 or more cavities and that yield a threaded product practically ready for use. The plastic molding cycle is usually one minute or more in length but yields so many parts per cycle that competition with metals, that weigh much more per piece and require more secondary operations, is almost impossible unless there are some unusual or compelling reasons for using metal. This, however, is almost the only class of part producible by impact extrusion, in which plastics offer effective competition.

Screw Machine Products

Although some parts made by impact extrusion can be produced alternatively on the screw machine, there is actually not much competition unless it be in short open tubes that can be cut on the screw machine from drawn or hydraulically extruded tubing.

Cup-shape parts can be turned out on the screw machine but the process is not fast as compared with impact extrusion and the waste in chips is high. These may be offset in some cases by operations, such as threading or tapping, knurling or bead rolling, that would be secondary on extruded products, but these would be unusual cases.

The screw machine can use metals, including ferrous types, not adaptable for extrusion and produce shapes which the extrusion press alone cannot turn out. In general, however, there is not much competition between these two types of products, except where the quantities are so small that die costs and setup time for extrusion may offset the faster production and minor scrap losses of the impact extrusion process.

Conclusion

From the foregoing, it is clear that impact extrusions have a field of utility in which they are and promise to remain more or less unchallenged by products made in other ways. Except for the economies offered and for the excellence of the products made by impact extrusion, the process could hardly have attained its present importance.

There are, however, many border line cases in which other processes can and do compete successfully, just as there are cases in which the makers of impact extrusions may take certain items away from makers of stampings, press forgings, die castings, plastic moldings, or screw machine products. It is the business of the process engineer to examine alternative processes and to select that best able to meet particular needs.

Acknowledgment

In the preparation of this article, the author had the cooperation of engineers of some companies that make extrusions, to whom he is most grateful. It does not follow, however, that they are in complete agreement with the author. Some particulars have been taken from articles mentioned in the bibliography.

Bibliography

Marcus A. Fair, "*Impact Extruded Aluminum Parts, Their Design and Production*" Product Engineering, June, 1945.

J. R. Boston, "*Cold Impact Extrusion of Aluminum Parts for Douglas Aircraft*" Machinery, July, 1945.

Herbert A. Hall, "*Designs That Can Be Made by Impact Extrusion*" Product Engineering, September, 1934.

John H. Friden, "*Sound Engineering Balances Cost with Expected Results*" Machinery, 1934.

Ellsworth Sheldon, "*How Collapsible Tubes Are Made from Soft Metal*" American Machinist, June 25, 1925.

CONTENTS NOTED

A monthly department dedicated as a forum for the interchange of ideas between readers and editors. All readers are urged to take advantage of this space and participate in the discussions presented.

Casting Bronze in China

To the Editor:

In China, especially in Szechuan, melters adhere to the practice of melting brass in sandstone crucibles, having a capacity of about 70 lb. The sandstone, a natural refractory material with a high silica content, could be found almost anywhere in Szechuan.

In making bronze castings, difficulties are often met in using the sandstone crucibles because of the higher casting temperatures. As a result of our own experiments, we conclude that the best casting temperature is around 2264 F. Our experiments are carried out by means of a single phase 35 kva. spark gap type high frequency induction furnace supplied by Ajax Electrothermic Corp. It was installed in the Metallurgical Laboratory in Nanking in 1935 and moved to Szechuan during the war under somewhat handicapped conditions.

For the water supply, a wooden cistern 5 ft. high and 4 ft. in dia. was built and placed just outside the window of the furnace room. The improvised pumping system driven by a 1-hp. motor provided a very convenient cooling system. The furnace was sometimes run continuously for 12 hr.

A Kipp's generator is used to produce the hydrogen atmosphere for the spark gap. The Kipp's generator is connected through a safe bottle to a gas holder made from a 50-gal. gasoline drum with one side sawed-off. The tank is immersed in the water held in another wooden cistern. An appreciable amount of hydrogen could be stored before the melting started.

Within the furnace coil a clay-graphite crucible was lined. The first crucible lasted 85 heats. It took less than 2 hr. for the first melting when copper blocks melt. The crucible has a capacity of 19 to 20 lb. for bronze. When a silica crucible was used, it took 3 to 4 hr. for a single melt. In this respect the clay-graphite crucible is definitely better for bronze making when high frequency induction heating is utilized.

L. C. Tai

Bureau of Material Research,
Directorate of Ordnance,
Chungking, China.

We are sorry we did not have room to print more of Mr. Tai's interesting letter, but we believe that the portions printed will give some idea as to how China has kept producing under adverse conditions.—The Editors.

Tin Undercoats

To the Editor:

Under *Blueprints* in the February issue of MATERIALS & METHODS mention is made that tin undercoatings before painting are easier and cheaper to apply than phosphating. Unfortunately, there was a bit of a mix-up on the amount of tin applied. We are not sure of your source of information, but feel reasonably sure that what was meant was 0.5 to 2.0 lb. per base box in place of 0.5 to 2.0 oz. per sq. ft.

In the Tin Research Institute General Report for the years 1942-1944 (p. 16), the thickness is given as 0.00003 in. or 0.5 lb. (8 oz.) per base box. In Wernick's paper, "Protective Value of Electro-Tin as an Undercoating" (*J. Electrodepositor Tech. Soc.*, Vol. 20, 1944, pp. 47 to 60), most of the experimental work was with 0.0001-in. coatings of tin or about 1.5 lb. per base box. Since a base box is about 218 sq. ft. of tin plate (436 sq. ft. of surface), there is quite a difference in the real and reported thickness.

The amount of tin required as an undercoating is in the electrolytic-tin plate range, hence there is a possibility that excess capacity of the electrolytic-tin plate lines might be used for making tinned stock for purposes other than cans when tin again becomes fully available. This is not a prophecy, but electro-tin as an undercoat is good enough to bear watching.

Bruce W. Gonser

Battelle Memorial Institute,
Columbus 1, Ohio.

Our thanks to Mr. Gonser for correcting us on this point. There is indeed a vast difference between the thickness of coating originally stated and that which is actually used.—The Editors.

(Please turn to page 1339)

CONTENTS NOTED

Continued from page 1337

Processing Equipment Directory

To the Editor:

We are returning to you a list of products which we fabricate. We wish to thank you for the opportunity of including our name in your Processing Equipment Directory.

Please be assured that all departments of this company are appreciative recipients of MATERIALS & METHODS. We have received many good ideas from the above-mentioned publication, and desire to express our gratitude to you for having a magazine of this type available to manufacturers and fabricators of metals and alloys.

Thomas J. Featheringham

The Youngstown Welding & Engineering Co., Youngstown 9, Ohio.

May we take this opportunity to thank Mr. Featheringham for his statement as to the value of MATERIALS & METHODS *and at the same time also to thank his company and the hundreds of others for helping us to compile what we believe will be the best directory of its type ever published by a magazine. The directory will appear in our June issue.*—The Editors.

German Technical Information

To the Editor:

May I ask your assistance in putting before your readers a request for their cooperation in an undertaking of great importance to American industry?

The Office of the Publication Board and the War Department are about to begin a complex operation: the selection and microfilming in Germany of data that may be valuable to American science and industry. We need advice.

This combing of German technical documents is the second phase of work begun by the Technical Industrial Committees. Teams of experts from industry made surveys of each industrial field in Germany immediately after fighting ceased. These experts were usually unable to make a detailed study of the documents uncovered by their investigations.

There are many tons of these documents, and to review them will require months of work by qualified technicians. We know that these documents contain priceless information. TIIC investigators found many new formulas, products and processes which American industry is already beginning to use.

We want industries and scientific groups to suggest specific information that should be sought . . . what industries might possess information not now available.

Qualified technicians in a number of industrial fields are needed to carry on the work of searching German files. These fields are: chemicals, aeronautics, machine tools, general industrial equipment, fuels and lubricants, metals and minerals, communications equipment, scientific instruments, shipbuilding and textiles.

Any industry or scientific group interested in specific industrial methods and able to assign personnel to visit Germany should get in touch with us. If the project appears to be of value to American industry, we will make the necessary arrangements. Information so obtained must be made available to all industry.

This is part of our reparations from Germany, in which any American can share directly. The danger is that we may not take full advantage of this opportunity while we can.

John C. Green

Executive Secretary,
Office of the Publication Board,
Dept. of Commerce,
Washington 25, D. C.

Treated Die Castings

To the Editor:

Will you please give us the name of the concern referred to in your notation on page 620 (Blueprints) of the February 1946 issue of MATERIALS & METHODS.

We are interested in finding a synthetic rubber coating to be applied to Alcoa #218 die castings. The chemical industry is using a rubber coating of paint and pipe lines which may be economically applied and stand up under severe usage conditions.

We are running into severe difficulty due to galvanic corrosion between certain essential stainless steel parts and the #218 aluminum alloy. We are considering the use of insulating coatings of synthetic rubber, organic or synthetic enamel, or any other material suitable for this purpose. The parts are subject to normal rough usage in handling, and will be washed daily in water up to boiling temperatures with ordinary sterilizing and cleaning solution. The material will be subject over temperature ranges of 0 to 180 F in normal use. If you can suggest any other suitable material we should be very pleased to have your suggestions.

H. F. Swenson

Sweden Freezer Mfg. Co.,
Seattle 7, Wash.

The material described in the Blueprint *referred to is described in a patent issued to Donald V. Srabach, Cuyahoga Falls, Ohio, and assigned to B. F. Goodrich Co.*—The Editors.

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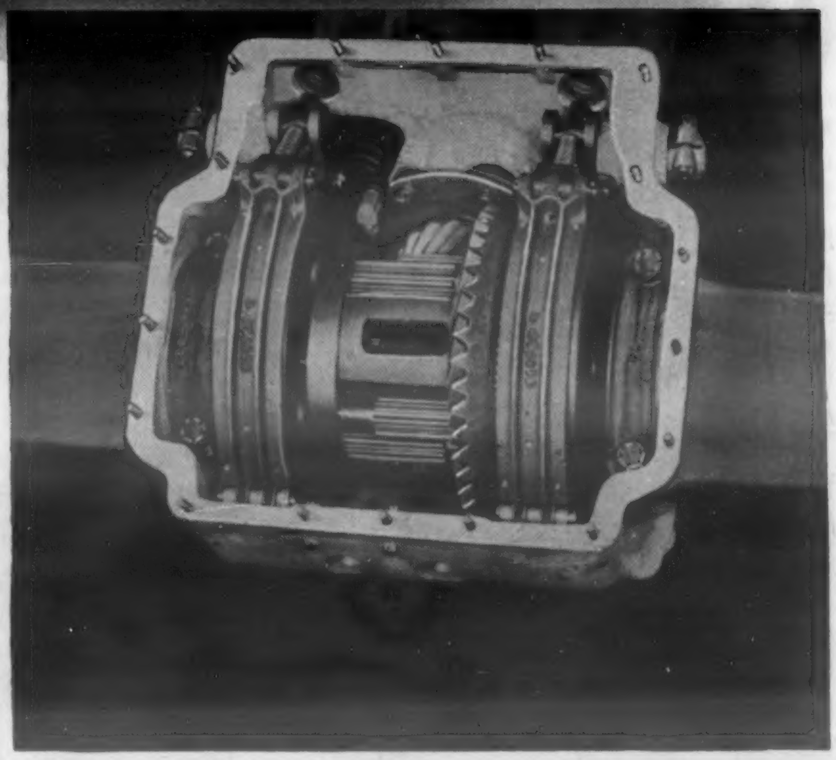
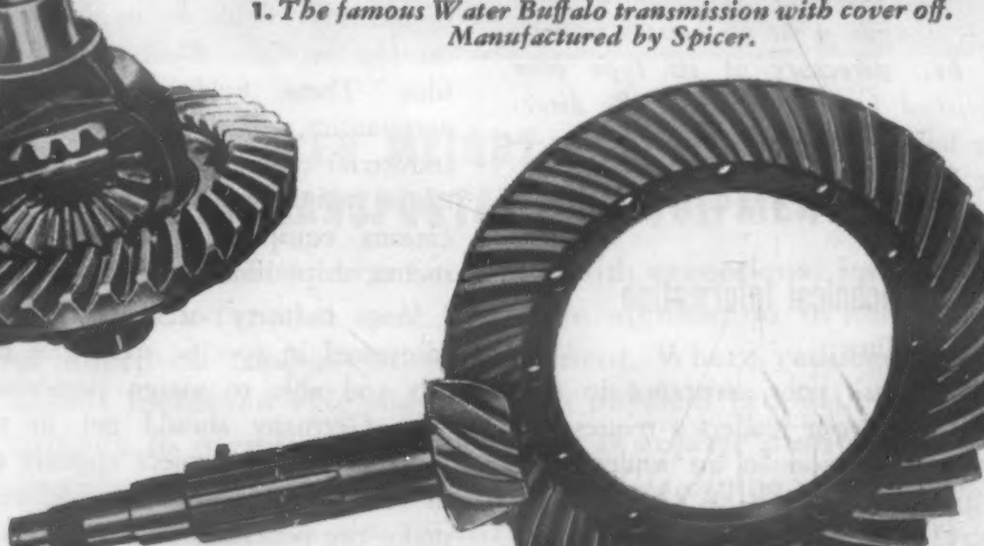


1. The famous Water Buffalo transmission with cover off. Manufactured by Spicer.

2. Spicer hypoid differential and pinion for the Willy's "Jeep".



3. Spiral bevel gear and pinion, manufactured by Spicer for the Studebaker "Weasel" Amphibian.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

MATERIALS & METHODS Engineering File Facts

NUMBER 114
May, 1946

MATERIALS: General

Shear Properties of Metals and Alloys

Part I: Copper Alloys, Nickel Alloys, Irons and Steels [1, 2]

Material	(Name and Specification No.[3])	Condition[7]	Shear Strength, Psi. (x 1,000)	Modulus of Elasticity in Shear, Psi. (x 1,-000,000)	Ratio of Shear to Tensile Strength	Remarks
Copper and Copper Alloys	Copper, electrolytic tough pitch (ASTM B5-43)	1-in. dia. rod, hot rolled	23.9	6.0-6.8[4]	0.76	T.S.[8] 29.9
	Beryllium-copper, (ASTM B120-41T)	Soft, annealed	55.0	—	0.69	—
		Soft, annealed then heat treated	95.3	—	0.64	
		Hard drawn, 30% reduction	69.1	—	0.73	
		Hard drawn, aver. heat treatment	84.6	—	0.48	
		Hard drawn, max. heat treatment	100.0	6.4	—	
	Brass (70-30)	Rod, cold drawn	34.4	5.5-6.0[4]	0.72	T.S.[8] 42.1
	Brass (34-38% Zn)	Wire, cold drawn	—	4.8	—	
	Brass (Muntz Metal, 60-40)	HR, quench., reheated[6] 480 F	55.3	—	0.73	T.S.[8] 54.8
	Brass (Muntz Metal, 60-40)	HR, quench., reheated 840 F	41.0	—	0.63	T.S.[8] 45.3
	Brass (73-27) (SAE 80A)	Cold worked	—	5.0-5.5[4]	—	
	Phosphor bronze (SAE 77A)	Wire, cold drawn	—	6.2-6.5[4]	—	
		Rod, cold rolled	37.0	6.5	0.63	T.S.[8] 52.6
	Tobin bronze		—	5.1		—
Nickel and Nickel Alloys	Commercial nickel (ASTM B160-41T)	Rod, hot rolled	—	11.3	—	—
		Rod, annealed	57.6	11.0	0.75	
	Monel (ASTM B164-41T)	Soft	49.2	9.0-10.0[4]	0.70	
		Half-hard	54.7	—	0.71	T.S.[8] 91.9
		Hard	65.2	—	0.56	T.S.[8] 94.6
	Inconel (ASTM B166-41T)	Soft	56.0	11.0	0.71	—
		Half-hard	67.2	11.0	0.68	
		Hard	82.9	11.0	0.54	
	K-Monel (Fed. QQ-N-286)	Soft	65.3	—	0.67	—
		Soft, age hardened	96.5	—	0.65	
		Half-hard	71.0	—	0.58	
		Half-hard, age hardened	98.8	—	0.64	
		Full-hard	89.5	—	0.59	
		Full-hard, age hardened	98.5	—	0.58	
	Z-Nickel	Soft	67.5	—	0.64	—
		Soft, age hardened	116.0	—	0.63	
		Half-hard	89.0	—	0.55	
		Half-hard, age hardened	104.0	—	0.52	
		Full-hard	100.0	—	0.50	
		Full-hard, age hardened	111.0	—	0.53	
Iron	Iron	Rod	41.2	11.5	0.68	—
	Malleable cast iron[9]	Annealed	48.0	12.5	0.84	—
	Malleable cast iron,[9] (pearlitic)	H. T.[10]	—	7.7	—	—
		H. T.[11]	—	7.5	—	
		H. T.[12]	—	7.2	—	
	Malleable cast iron,[13] (pearlitic)	H. T.[14]	—	9.6	—	—
		H. T.[15]	—	9.5	—	
		H. T.[16]	—	8.1	—	
	High strength cast iron (Meehanite GA)	As cast	48.0	—	0.96	T.S.[8] 60.0

(Continued on page 1343)

NUMBER 114 (Continued)

SHEAR PROPERTIES OF METALS AND ALLOYS, PART I

Material	(Name and Specification No.[3])	Condition[7]	Shear Strength, Psi. (x 1,000)	Modulus of Elasticity in Shear, Psi. (x 1,000,000)	Ratio of Shear to Tensile Strength	Remarks
Iron (Cont.)	Cast iron[17]	As cast	60.8	—	1.27	—
	Cast iron[18]	As cast	47.3	—	1.16	
	Cast iron[19]	As cast	44.6	—	1.37	
	Cast iron[20]	As cast	27.7	—	1.39	—
	Cast iron (7/8-in. dia. bar)[21]	Cast in perm. mold, annealed	43.8	7.4	1.29	
	Cast iron (2-in. dia. bar)[21]	Cast in perm. mold, annealed	36.5	6.3	1.62	
	Alloy cast iron[22]	As cast	73.0	8.6	1.57	—
	Alloy cast iron[23] (2½-in. dia. bar)	As cast	86.0	6.5	1.12	
	Alloy cast iron[24]	As cast	48.7	5.1	1.32	
	Alloy cast iron[25]	As cast	79.2	7.1	1.46	
	Alloy cast iron[26]	As cast	47.0	7.1	1.12	
	Stainless iron[27] (3-in. dia. bar)	Hot rolled	68.5	12.4	0.83	—
Steel	0.30% C cast steel[28]	As cast	—	—	—	T.S.[5] 60.5
		Annealed[29]	—	—	—	T.S.[5] 59.5
	0.30% C steel (SAE 1030)	Annealed[30]	75.9	11.8	1.00	—
		H. T.[31]	90.6	12.0	0.99	
	0.40% C steel (SAE 1035)	Annealed[32]	79.8	11.7	1.05	—
		H. T.[33]	96.7	12.4	0.97	
	0.45% C wire (0.250-in. dia.) (SAE 1045)	H. T.[34]	—	11.3	—	—
	0.55% C steel (1½-in. dia. bar) (SAE 1060)	H. T.[35]	74.9	11.4	0.70	
	0.67% C wire[34] (0.062-in. dia.)	H. T.[34]	—	11.6	—	
	0.70% C wire[36] (0.039-in. dia.)	Oil tempered	—	10.9	—	
	0.83% C wire[37] (0.080-in. dia.)	H. T.[34]	—	11.4	—	
	0.91% C steel[38]	H. T.[39]	—	10.8	—	
	0.33% C, Cr-Mo steel (SAE 4130)	Annealed[40]	87.4	12.0	1.14	—
		H. T.[41]	114.0	11.8	0.91	
	0.50% C, Cr-Mo steel[44] (sim. to SAE 4150)	Annealed[42]	—	—	—	T.S.[5] 76.7
		H. T.[43]	—	—	—	T.S.[5] 126.0
	0.50% C, Cr-V wire 0.040 (SAE 6150)	H. T.[45]	—	11.2	—	—
	0.50% C, Cr-V steel	H. T.[46]	—	11.2	—	
		Annealed[47]	—	—	—	T.S.[5] 77.0
		H. T.[48]	—	—	—	T.S.[5] 110.0
		H. T.[49]	132.0	—	0.65	
	0.30% C, manganese steel (SAE 1330)	Annealed[50]	84.3	12.0	1.00	—
		H. T.[51]	101.0	12.1	0.90	
	0.43% C, nickel steel (sim. to SAE 2340)[54]	Annealed[52]	90.6	12.1	0.96	—
		H. T.[53]	107.0	11.7	0.91	
	0.40% C, Ni-Cr steel (SAE 3240)	Annealed[55]	90.6	11.3	1.01	—
		H. T.[56]	115.0	12.1	0.89	
	0.32% C, Ni-Cr-Mo steel (sim. to SAE 4330)[59]	Annealed[57]	95.8	11.5	1.00	—
		H. T.[58]	112.0	11.7	0.80	

(Continued on page 1345)

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TA-1360

NUMBER 114 (Continued)

SHEAR PROPERTIES OF METALS AND ALLOYS, PART I

(Footnotes applying to the two preceding pages)

[1] *Part 1 includes the shear properties of copper alloys, nickel alloys, irons and steels; Parts 2 and 3, to be published in forthcoming issues of* MATERIALS & METHODS, *will deal with the alloys of aluminum and magnesium*

[2] *Data taken from A.S.T.M.* Standards, *Part 1, 1944 Ed.; from* Metals and Alloys Data Book *(Reinhold Publishing Corp., N. Y.), Circular C 447 (National Bureau of Standards), and from information supplied by the International Nickel Co., Inc.*

[3] *If the composition of the material reported upon falls within the limits of a recognized specification (A.S.T.M., S.A.E., etc.), that specification number will be given, otherwise the composition will be given*

[4] *Where a range is given, it is due to an expected variation in composition or in the degree of thermal of mechanical treatment*

[5] *Torsion strength x1000 (psi.)*

[6] *Abbreviations used in this table:*
HR, Hot Rolled; CR, Cold Rolled; Quench. or Q, Quenched

Table of Chemical Composition (In Percent)

Footnote No.	Total Carbon	Graphitic Carbon	Mn	Si	S	P	Others
8	1.75-2.30	—	0.40	0.85-1.20	0.12	0.20	—
9	2.45	—	—	1.46	—	—	—
13	2.51	—	—	1.4	—	—	Mo 0.49
17	2.50	1.50	0.74	0.79	0.09	0.04	—
18	2.88	2.25	0.51	1.99	—	0.43	Ti 0.05
19	3.12	2.44	0.44	2.18	0.10	0.63	—
20	3.41	2.85	0.57	2.44	0.07	0.63	Ti 0.10
21	3.52	3.41	1.01	2.55	0.068	0.215	—
22	3.28	2.47	0.95	2.19	0.10	0.17	Mn 0.95, Cr 0.42
23	2.65	—	1.18	2.48	—	—	Ni 1.21, Mo 1.15, Cr 0.17
24	3.24	—	0.43	1.41	—	—	Ni 1.30, Cr 0.21
25	2.76	—	0.75	2.07	—	—	Ni 1.57, Mo 0.69
26	3.36	2.39	0.92	1.22	0.11	0.12	Ni 1.87, Cr 0.47
	C	**Mn**	**Si**	**S**	**P**	**Cr**	
27	0.03	—	—	0.01	0.04	13.47	V 0.27
28	0.33	0.77	0.32	0.036	0.04	—	—
35	0.67	0.68	—	0.045	0.045	—	—
36	0.70	0.42	—	—	—	—	—
37	0.83	0.38	—	0.045	0.045	—	—
38	0.91	0.38	0.16	0.037	0.036	—	—
44	0.50	0.48	0.24	—	—	1.03	Mo 0.19
54	0.43	0.64	0.20	0.023	0.015	—	Ni 3.47
59	0.32	0.60	0.16	0.019	0.014	0.86	Ni 1.92, Mo 0.30

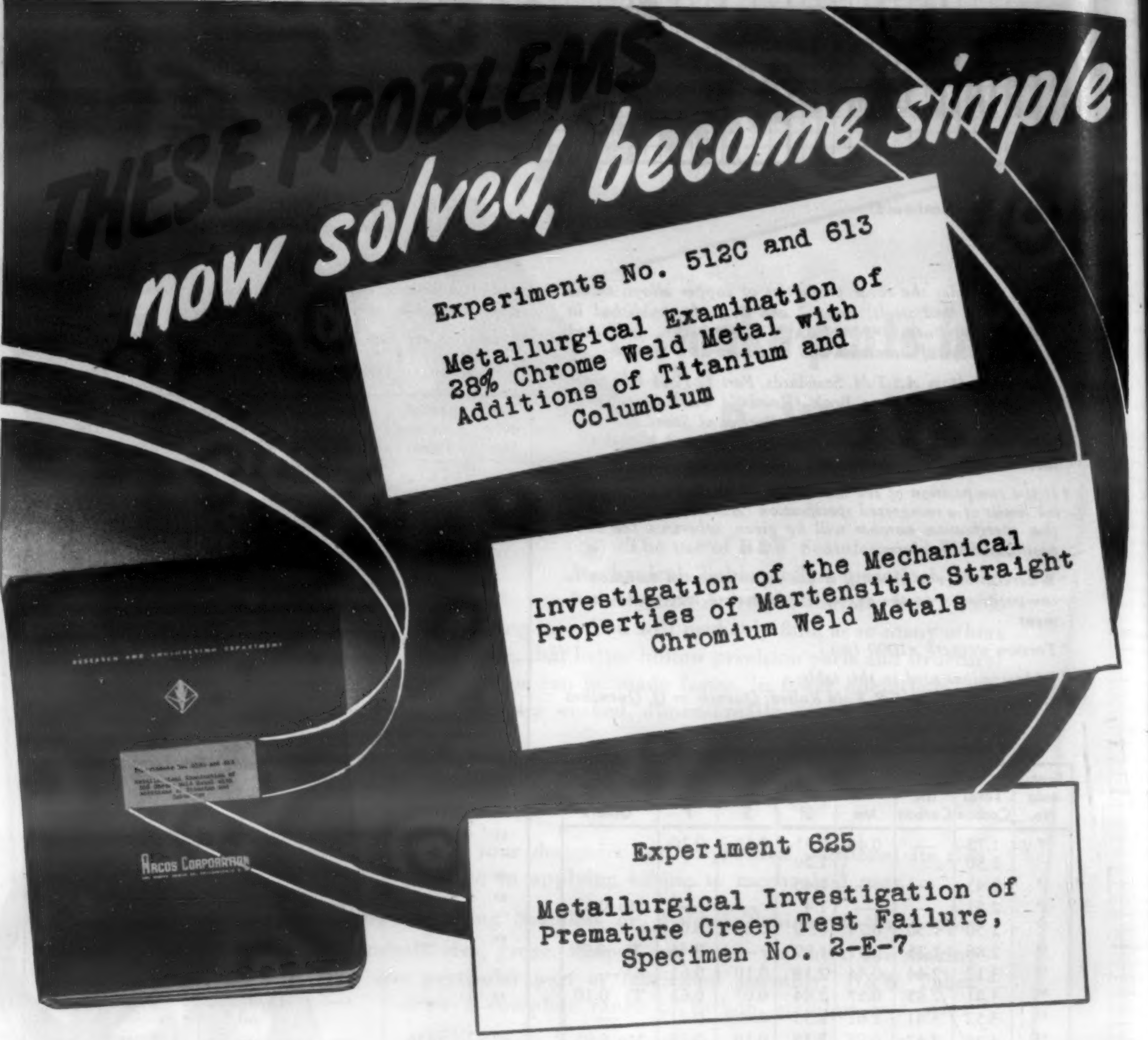
[7] *Unless otherwise stated, the material is understood to be in a wrought condition*

[34] *Quenched, tempered, coiled and tempered at 850 F*

Table of Heat Treatments (All Temperatures in Deg. F)

Footnote No.	Anneal. Time and Temp.	Cool to-	Holding Time and Temp.	Quench From-	Temper. Time and Temp.
10	15 hr. at 1700	1525 in 2 hr.	—	1525 into oil	2 hr. at 1325
11	15 hr. at 1700	1525 in 2 hr.	—	1525 into oil	4 hr. at 1325
12	15 hr. at 1700	1325 in 3 hr.	20 hr. at 1325	(Air-cool)	—
14	15 hr. at 1700	1525 in 2 hr.	—	1525 into oil	2 hr. at 1325
15	15 hr. at 1700	1525 in 2 hr.	—	1525 into oil	4 hr. at 1325
16	15 hr. at 1700	1325 in 3 hr.	20 hr. at 1325	(Air-cool)	—
	Anneal. Temp.	**Normaliz. Temp.**	**Quench From-**	**Tempering Temp.**	**Remarks**
28	1700	—	—	—	—
30	1450	—	—	—	—
31	—	—	1600 into water	1100	—
32	1450	—	—	—	—
33	—	—	1600 into water	1100	—
35	—	1600	1550 into water	1200	Cooled in furn. to 900
39	—	—	1575 into oil	940	—
40	1450	—	—	—	—
41	—	—	1600 into oil	1100	—
42	1600	—	—	—	—
43	—	—	1600 into water	900	—
45	—	—	1690	212	—
46	—	—	1600 into oil	810	—
47	1650	—	—	—	—
48	—	—	1650 into water	1100	—
49	—	—	1650 into oil	860	—
50	1450	—	—	—	—
51	—	—	1525 into oil	1100	—
52	1450	—	—	—	—
53	—	—	1450 into oil	1100	—
55	1450	—	—	—	—
56	—	—	1530 into oil	1100	—

Compiled by Robert S. Burpo, Jr., Associate Editor



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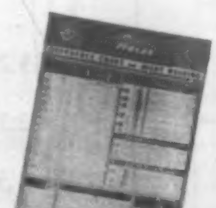
Constant research on special problems as well as on Arcos standard electrodes means that Arcos trade-names CHROMEND (one of the lime-type coatings for DC) and STAINLEND (titania coating for AC-DC) may be specified with full confidence.



Successful alloy welding often depends on having complete, correct information. Here is a text book in wall chart form — the Arcos Reference Chart on Alloy Welding. A copy will be sent you on request.

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engineering SHOP NOTES

Preventing Scale With a "Semi-Pack"

by R. B. Seger,
Lindberg Engineering Co.

There are many ways of preventing scale during heat treatment. One method that can be used when atmosphere furnaces are not available is the "semi-pack" method. Actually, as the name implies, the work is packed into a container, but instead of being surrounded by packing compound, it is surrounded by the atmosphere generated from the small quantity of charcoal in the bottom of the pot.

Two fire bricks are placed in the container. The container can be made of ordinary low carbon steel, but for repeated runs should be of alloy steel such as 35% nickel-15% chromium type.

Charcoal is sprinkled around and between the bricks. For best results, the charcoal before being used should be heated to about 1600 F to drive off the volatile matter and water vapor to prevent decarburization. The work must not be allowed to contact the charcoal.

With the cover on the container the work can be charged directly into the furnace on the first heat. Thereafter, a 500 to 700 F preheat is recommended. Heating time in the pack is somewhat longer than open fire heating. Generally, furnace temperature must be run 25 to 50 F higher than the desired work temperature in the pot.

On small parts the charcoal will last for several heats, and need not be replenished until it is nearly spent.

This method can be applied to most steels hardening below 1800 F. Although this is neither an economical nor practical method for production heat treating, it is quite suitable for the occasional job.

Courtesy of "Heat Treating Hints"

Gears about to be "semi-pack" hardened. Charcoal has already been sprinkled around the bricks.

Infrared Spectroscope

by Donald K. Coles,
Westinghouse Research Laboratories

Not only will the infrared spectroscope prove valuable in its practical applications to industrial processes, but as a pure research tool it should enable scientists to uncover hitherto unknown facts about molecular structures and provide fundamental data such as led to the development of the X-ray, radar and atom splitting. The instrument is particularly effective with oil, chemicals and plastics.

The infrared spectroscope with its invisible beam of light "fingerprints" each component of the material and does its work many times faster and more accurate than any previous method. A sample of the studied material is placed in a special holder. Then a beam of infrared light is directed through it by heating a silicon carbide rod to an incandescent glow. Highly polished mirrors and special prisms guide the light along a 30-ft. long zigzag path to highly sensitive receivers that convert the light into electrical current, amplify it, and record the information with an electronic pen on a chart outside the machine.

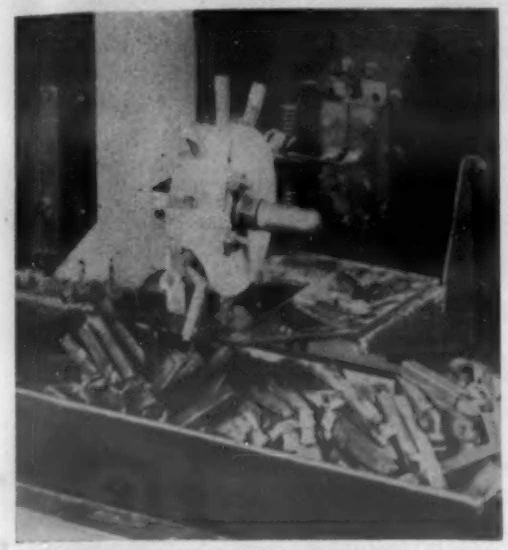
Molecules that make up all matter vibrate at certain characteristic frequencies —millions or even billions of times a sec. The spectroscope quickly ferrets out this frequency by "tuning" the frequency of the infrared beam to that of the material under study—just as one tunes a radio set to the frequency of the station wanted.

When the two vibrations coincide, the material absorbs the infrared beam, which is recorded on the chart by a moving pen. The operator matches this frequency against a standard previously determined and thus identifies the material as accurately as fingerprints reveal human identity. Any impurities are detected instantly. The infrared is, of course, the most modern of spectroscopes.

Rotary Fixture for Brazing Cutting Tool Tips

by William E. Benninghoff, Tocco Div., Ohio Crankshaft Co.

A handy fixture has been developed for induction heating equipment to greatly speed up the brazing of tungsten carbide tips to cutting tools. A rotary fixture, it was designed to hold the tools during the brazing operation. The fixture is a transite block 6 in. in diam. with a 1½-in. face mounted on a revolving spindle attached to an upright support. It can handle 20 tools ranging in size from ¼ in. to ¾ in. square and of moderate length.



View of rotary fixture for brazing tips to cutting tools, with tools in place ready for brazing.

Three bolts hold the rotary block, which can be removed to allow for a change in size of shank. Since the mechanism of the fixture is attached to a stationary bracket, an adaptor plate is used when changing to another size. The tools are held in the fixture by spring tension.

The operator rotates the block manually to allow each tool, in turn, to enter the field of the inductor coil, where it becomes heated. The tip is "wiped" in place by the operator during the heating, after which the tool passes down and out of the inductor. Because the flux is sufficiently adhesive, it is not necessary to hold the tip in position by any other means as the tools pass into and out of the inductor. Held by mechanical tension until it arrives at the vertical, the tool is released automatically from the fixture.

Testing Temperature by Alloy Colors

by A. J. Nerad, General Electric Co.

A chromium cobalt alloy shows a marked color change for every 25 degree Centigrade change in temperature from 500 C to 700 C, then reverts back to its original color and begins the color scale over again in a higher range from 725 to 900 C (1652 F). By making gas turbine parts of this alloy, the operating temperature of a turbine has been ascertained for the first time and by General Electric engineers. There will probably be other adaptations of this color-changing alloy.

The alloy changes color when being oxidized under heat. Unlike other metals, however, it oxidizes so slowly at higher temperatures that each color change occurs regularly at 25 deg. intervals. On the basis of 1-hr. heat treatment, the alloy at 500 C turns a light straw color; at 525 C, a straw color; at 550, a bronze hue; at 575, purple; at 600 dark blue, etc.

It turns light blue at 700 C and, theoretically, should next turn grey. However, at 725 it reverts back to a light straw and begins the procession over again. It begins to show greying tendencies at 925 C. Interference colors of the alloy change as the thickness of the oxide film changes, until the film becomes so thick or irregular that no color is transmitted through it to be reflected. By now the metal is no longer useful for measuring temperature.

The film of oxide on the alloy increases in thickness only two and one-half billionths of an in. at every 25 deg. change in temperature.

Assembly by Chilling, Heating and Pressing

by A. F. Denham, Colonial Broach Co.

An ingenious set-up combining severe freeze, heating, and hydraulic presses for assembling eight steel sleeves in the bores of a V-type cylinder block has been in use by a well-known engine manufacturer. The process was worked out in cooperation with Colonial Broach Co., Detroit, who designed and built the special assembly presses used.

The steel sleeves are cold-treated by refrigeration at the same time the blocks are being heated. The chilled sleeves are pressed in two at a time on a dual Colonial press (Fig. 1). The cylinder block is indexed into position for each subsequent pair of sleeves. Spring loaded plungers, which contact index grooves on the side of the fixture slide, insure alignment.

Fig. 1—The chilled sleeves being pressed into the cylinder block.

When block and liners return to room temperature after this operation, the liners assembled develop a tendency to "crawl" up out of the bores. It thus is necessary to "set" the sleeves after cooling. For this the special press shown in Fig. 2 is used. This press operates on a combination of hydraulic pressure and impact. The platen is inclined so as to automatically align each row of bores with the plunger of the press. Locating stops in the raised strip on the platen position the cylinder block for each sleeve.

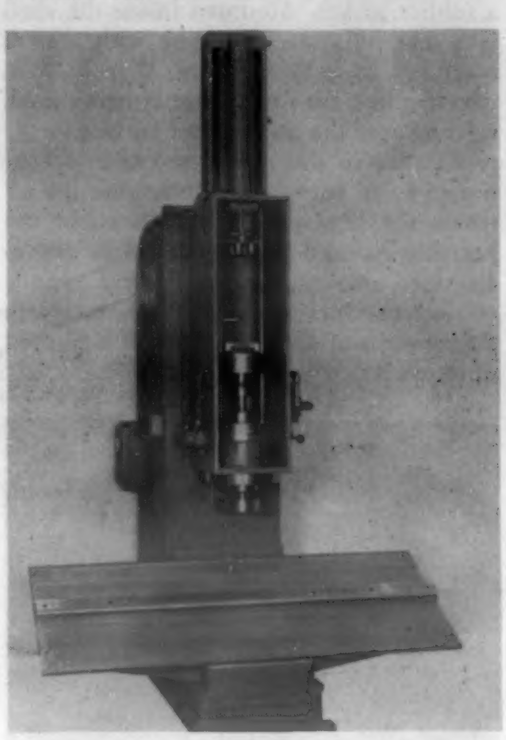


Fig. 2—This press is used for "setting" the sleeves in the bores after cooling.

To set the sleeves, hydraulic pressure is applied by a piston in the ram. At the same time, air pressure lifts a weight above the hydraulic piston. At the top of the column, the weight is tripped and dropped on the hydraulic piston plunger. This produces an additional impact load, which drives the sleeve and sets it in the cylinder bore.

Westinghouse engineers recently ran to earth the reason for a most mysterious but also annoying local epidemic of excessive gear wear. As so often the case, the cause was a simple one. Fly ash or other abrasive dust was getting into the lubricating oil. That hard dirt particles in gear lubricant are not good is not a new idea, of course. But it had not been generally appreciated how little abrasive dust—fly ash, ore dust, or even log-bark dust—need be present for consequences to be serious. In one case, gears of a turbine-driven induced draft fan were wearing and becoming noisy in the matter of days. Analysis of the lubricating oil indicated a small amount of fly ash. Applying adequate oil filters completely solved the trouble.

—Westinghouse Electric Corp.

Measuring Sheet Metal Thicknesses With Air Pressure

A new type instrument gage operating on the pressure principle has been developed to measure thicknesses of sheet metal stock. It is also applicable for the inspection of the bonds between laminar layers of laminated materials.

The gage consists of an inverted cup-shaped shell with a top wall of transparent material and the bottom rim edged with a rubber gasket. Mounted inside the shell is a dial indicator equipped with a stem reaching to a spherically shaped foot, which, when the instrument is being used, rests against the metal sheet surface.

A valve in the top of the case is connected to an exterior pump so that the air inside the gage can be withdrawn or the pressure reduced to any desired or predetermined amount. The dial of the gage is of conventional design which measures thousandths of an in. as the foot is pushed upwards.

The gage in position on a sample to measure the metal thickness.

To use the gage it is placed on the area to be inspected, the valve is opened and the air inside the instrument allowed to reach normal atmospheric pressure. A reading is then taken which acts as a "standard" for the test. With the valve again closed, the air is evacuated thus reducing the pressure on that side of the sheet. Because of the difference in pressure, the sheet metal is deflected upwards, pushing the foot of the gage up. This deflects the dial on the gage, giving an indication of the metal thickness.

The instrument may be so calibrated for laminated materials being inspected that for a particular material a deflection of certain degrees can be readily interpreted as a faulty bond in a particular layer.

Courtesy of The Glenn L. Martin Co.

In a certain soldering job ordinary methods, such as using an iron, an open flame, or induction heating to melt the solder, was impractical. Some way had to be found by Bell Laboratories and Western Electric to anchor tiny wafers of quartz crystals, some only 1/8-in. square, gently but firmly in place. They must be mounted solidly so that they touch nothing except two to eight lead wires which must be attached to an exact spot on one surface of the crystal. The answer was a hot air soldering fixture that may be adjusted to accommodate many sizes of crystals. The time interval must be short. A fine stream of heated air offered the only solution.

—"Research and Engineering," Western Electric Co.

Hardening Steam Hammer Piston Rods

By W. L. Redding, for Heppenstall Co.

More than two years of field service testing has indicated to Heppenstall Co. that induction hardening of the ram taper area of steam hammer piston rods makes possible a substantial increase in service life. Recognizing that a very large proportion of the normal piston rod failure is the classic fatigue type generally conceded to be caused by repeated tension stress and starting at the metal surface, the company has put into practice its findings.

This surface induction hardening of the piston rod ram taper has for its principal object the alleviation of service failures caused by metal fatigue in the ram taper within the ram, at or near the top of the taper.

Service failures of piston rods usually start on the surface of the rod, usually at some stress raising point such as a toolmark, nick, groove, or a misfit between rod and ram. The failure progresses from the surface inwardly until the section of the rod is so decreased that it can no longer resist the direct stresses encountered in service.

Heppenstall recognized that this type of failure was closely related to failures in automobile crankshafts. Surface induction hardening of these has greatly increased their service life. Heppenstall decided that an induction hardening of the surface was desirable, in addition to the conventional heat treating of the piston rods.

With the Ohio Crankshaft Co., a method was found whereby piston rods could be given a case hardening on the ram taper surface. The initial tests were conducted with the piston rods in a horizon position. Heppenstall now has installed a vertical induction heat treating apparatus that has definite processing advantages.

A heat treated, completely finished and ground piston rod, suitably preheated, is inserted in the new specially constructed machine. A water-cooled induction heating unit is slipped around the ram taper end. The rod is revolved at a speed commensurate with its size and the desired heating rate.

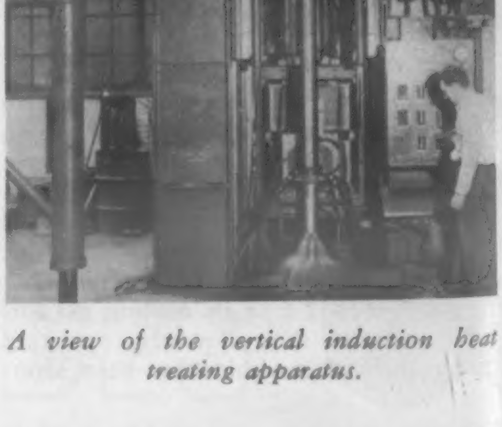
A pass is then made with the induction heating ring and quench spray. The rod surface is raised to 1600 F, and is progressively hardened on the surface by the immediate impingement of a traveling cold water spray attached directly beneath the induction ring.

This surface induction hardening process produces a hardened case approximately 3/16-in. deep from the surface of the ram taper inwardly and extending to a point slightly above the end of the taper. If desired, a rod may be produced that is surface hardened throughout its entire length.

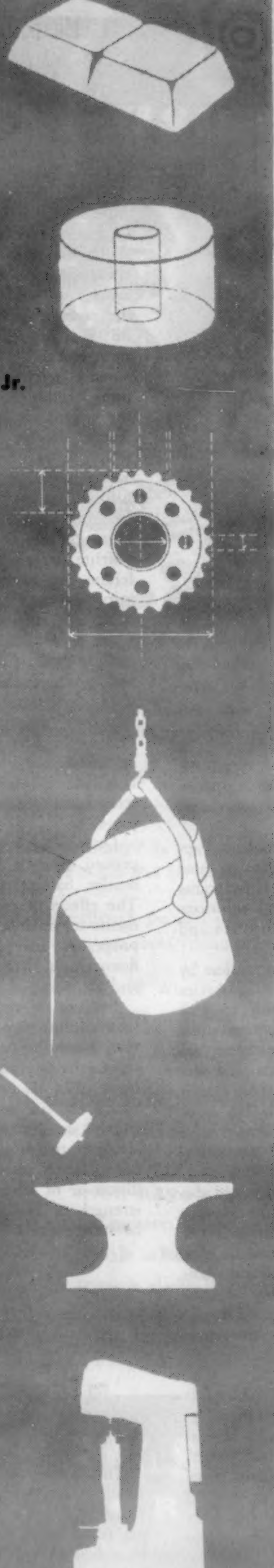
The effect is to produce a compressive stress in the skin which aids in counteracting tensile stresses that develop and which lead to service fatigue failure. As an example, should the surface tensile stress during service be approximately 40,000 p.s.i. which, if repeated, would cause progressive failure, and should the hardening process induce a compressive stress of 60,000 p.s.i. in the surface metal, the latter stress induced by the surface hardening treatment will counterbalance the 40,000 p.s.i. tensile stress that results from service stresses, and will leave a residual 20,000 p.s.i. compressive stress in the surface material. Under such conditions tension fatigue fractures will not initiate.

A typical rod, so hardened, will show a hardness through the cross section of 495 BHN on the surface, 302 at a depth of 1/4 in., 295 at 3/4-in. depth, and 285 at the center. The protective hardening of the ram taper surface does not change the ductile, yet high strength center portion which is necessary to withstand impact stresses.

Before placing these improved piston rods on the market, Heppenstall Co. tested them in steam hammers having from 8,000- to 35,000-lb. capacity. In one drop forge company, where a 10-in. diam. conventional rod averaged 210 working hr. in a 35,000-lb. hammer, the induction surface hardened rod served for 598 hr. In another plant, when installed in a 12,000-lb. hammer, the recently developed piston rod served for 434 hr., as contrasted with a 254-hr. average life for the conventional piston rod. Less surface galling was also noted.



A view of the vertical induction heat treating apparatus.



MATERIALS & METHODS DIGEST

A selection of outstanding articles on engineering materials and processing methods in the metal-working industries.

Edited by Robert S. Burpo, Jr.
Associate Editor, Materials & Methods

MATERIALS and DESIGN

Metals and Alloys

Nonmetallic Materials

General Product Design

METHODS and PROCESSES

Melting and Casting

Fabrication and Treatment

Testing and Inspection

METALS and ALLOYS

Engineering properties and applications of carbon, alloy and stainless steels, irons and nonferrous metals and alloys. Selection and evaluation of metallic materials for engineering service. New alloys and modifications.

Ferrous Metallurgical Research—Army Ordnance

Condensed from "Journal of Applied Physics"

The laboratory of the Watertown Arsenal, Watertown, Mass. has been established as the agency of the Ordnance Department primarily responsible for research and development in the field of ferrous metallurgy. One of the chief problems in this field is to develop a more complete understanding of the plastic flow and rupture properties required in ordnance steels, and the means by which these properties may be most efficiently obtained.

Every metal has, at least in concept, a fracture stress and a flow stress. This resulted in the establishment of a quantitative equivalence between the effects of strain rate and temperature on the behavior of steels. This has permitted the evaluation of the effect of strain rate on the behavior of steel as a function of metallurgical variables.

It has been demonstrated that the tempered martensitic structure, as contrasted to structures involving preferred orientations of carbide, is associated with a fracture stress behavior which, in relation to flow stress, is comparatively unaffected by adverse conditions, such as high strain rates, low temperatures, and multi-axial stress applications which tend toward brittle failure. Additional research proved the superiority of the tempered martensitic structure in steel for critical ordnance applications.

A concentrated effort has been made to arrive at a complete understanding of the nature of temper brittleness and its effect upon the properties of steel. Efforts are also being directed toward acquiring information which will make possible the synthesis of steels for fully hardened parts of any size.

The qualities required for the optimum performance of armor-piercing projectiles have been established, and progress has been made in achieving improved performance in the production of projectiles of artillery sizes through the application of these principles.

A recent study of the mechanisms of the transformations in steel has proved that alloying elements affect the rate of transformation to pearlite by rendering ineffective the sites within the lattice that are capable of nucleating the reaction. The constants that govern the effect upon the rates of transformation to pearlite and bainite have been determined for the individual alloying elements.

Electrical strain gages have been applied to the measurement of strains in guns under firing conditions. Other programs are devoted to the mathematical solutions of problems in the design of gun tubes and breech rings.

Demonstrations provided information by which the cast and rolled armor industries accomplished complete transition to low alloy types of steel within five months. Studies were made that determined the essential characteristics of armor and developed simple tests by which these qualities can be controlled. Research has been conducted to determine the characteristics required in thin armor to afford protection against shell, grenade and bomb fragments.

Research in metal arc welding has developed means which minimize the absorption of hydrogen during welding, and the path is clear to achieve progress in the welding of alloy steels with high strengths and using electrodes of low cost. Investigations are under way to determine the response of different steels to the complex thermal cycles resulting from multiple pass welded joints.

Studies have been conducted on methods of improving quenching efficiency in the best treatment of gun tubes, and innovations of procedure have been developed that materially reduce heat treating costs. Manufacturing deficiencies in the making of gun carriages and armored vehicles have been studied, and corrective measures have been instituted.

—N. A. Matthews. *J. Applied Physics*, Vol. 16, Dec. 1945, pp. 780-787.

Microstructure of Cast Iron

Condensed from "American Foundryman"

The effects of cooling rates on the microstructure, hardness and tensile strength of four different cast irons were studied by pouring solid cylinders of different sizes in sand molds with and without chills. The compositions of these irons were such that they were gray when poured in medium or heavy sections.

As the cooling rate increases (1) the tendency to form massive cementite increases and graphitic carbon decreases, (2) the pearlite becomes finer, (3) the graphite size decreases and the distribution changes, and (4) the tendency to form massive ferrite decreases. With thin sections or the use of chills, massive cementite begins to form, and a rapid drop in tensile strength and machinability occurs which is accompanied by an increase of hardness. Lowering of the total carbon and silicon content decreases the graphitizing tendency and increases the cementite stability. Thereby the formation of coarse pearlite, large graphite flakes, and massive ferrite are restricted and the irons have improved tensile strength and higher hardness, especially in thicker sections.

In regard to heat treatment, full annealing will eliminate massive cementite and promote the growth of ferrite areas with corresponding loss in hardness and improved machinability. Stress relief annealing imparts substantially no change in microstructure, tensile strength, or hardness but is beneficial in that it relieves stress and reduces distortion of finished parts.

Quenching and tempering result in improved strength through formation of martensite, bainite, etc. in the "steel" matrix. The effects of cooling rates and heat-treatments on final microstructures and physical properties may be modified by the influence of alloying elements on the graphite and matrix.

Because of variation in microstructure with cooling rate, it is important to notice that a tensile strength test on a test bar represents only the tensile strength of sections of a thickness similar to that from which the bar was taken. Heavier sections in the casting will have a lower tensile strength per unit of area and also lower hardness. A test-bar in the "as cast" condition is of little value in estimating the strength or hardness of a casting that will be subsequently heat treated.

—W. E. Mahin & H. W. Lownie, Jr. *Am. Foundryman*, Vol 9, Jan. 1946, pp. 20-28.

The Effect of Stresses on Fatigue of Aluminum Alloys

Condensed from "The Journal of the Institute of Metals"

This paper is divided into four parts: rotating-cantilever fatigue tests of two wrought and one cast aluminum alloy; tests on tubes with external annular notches; tests dealing with the effect of residual compressive stresses at the root of an annular notch; and fatigue tests on single spot

welds, some of which were pre-loaded in the direction of the subsequent application of the fatigue loads.

In the first case the stresses had little effect on the fatigue strength of plain (un-notched) specimens of wrought material. On specimens having annular notches, increases were obtained of up to 80% above the strength of samples not under residual stresses. In the third study the stresses were induced by pre-loading the specimen in tension, thus improving the fatigue properties 100% in the rotating-cantilever test. The fatigue strength of pre-loaded spot welds increased 50% over original welds under fluctuating shear stresses.

The main conclusion is that under the complex stress conditions at the root of the annular notch, compression stresses—whether applied by quenching or mechanical action—may result in an extremely large increase in fatigue strength. It is assumed that an increase of strength is, in fact, the result of a residual stress and that effects of other differences are small.

Measurements made on test pieces before and after pre-loading have shown that the change of shape of the notch was very small. As to the effects of cold work on the fatigue properties, it has been shown that for test pieces without notches, cold work by stretching after heat-treatment tends to have little effect on the fatigue strength of extruded duralumin-type material.

For aluminum alloys of the types dealt with it is assumed that quenching from heat-treatment temperature into water at room temperature will induce internal stresses of appreciable magnitude in samples of the dimensions used. For simple shapes the stresses will be compressive on the surface and tensile in the core, and their actual values may be expected to increase, within limits, with increasing size of specimen.

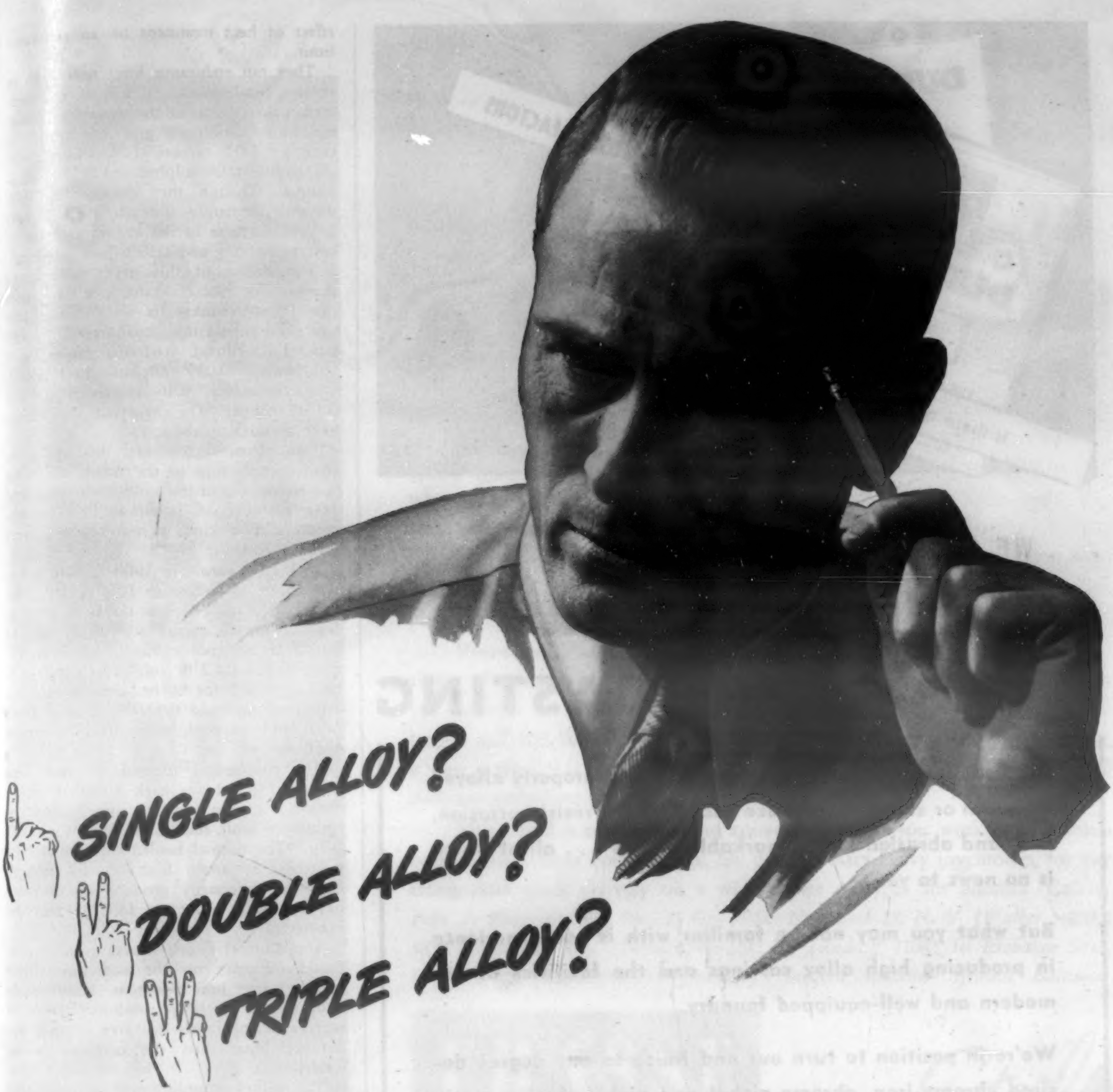
Studies of the tubes revealed that in the heat-treated and quenched state the stress is a longitudinal compression on the outside, with a corresponding tension on the inside, both of fairly large magnitude (the last operation had been heat-treatment, with no further mechanical action applied). The heat-treated and sunk material shows high tensile stresses on the outside and compression on the inside (these tubes were heat-treated when the outside diameter was 0.687 in. and then reduced to 0.625 in. by a heavy sinking pass).

—G. Forrest. *J. Inst. Metals*, Vol. 72, Jan. 1946, pp. 1-17.

Heat Treatment and Endurance Limit of Cast Iron

Condensed from "American Foundryman"

Considerable information is available on the heat treating of gray cast iron to increase tensile strength, but the effect of this treatment on the endurance limit has been largely neglected. Also the effects of size of section and original microstructure on the final heat treated tensile strength and endurance limit is an open field for investigation. Moore and Picco are the only ones who have reported results on the


SINGLE ALLOY?
DOUBLE ALLOY?
TRIPLE ALLOY?

effect of heat treatment on an endurance limit.

They ran endurance limit tests, both in reverse bending and in torsion, on specimens taken both in the as-cast and heat-treated condition on gray cast iron containing: 3.07 carbon, 1.26 silicon, 0.90 manganese, 0.08 sulphur and 0.15% phosphorus. Though they obtained a 58% increase in tensile strength, there is only a 19% increase in the endurance limit in reverse bending and a 30% gain in torsion.

The author of this paper investigated material for cast crankshafts of Meehanite iron. Two chankshafts were cast of the processed cupola iron, analyzing: 2.84 carbon, 1.40 silicon, 0.67 manganese, 0.11 phosphorus, 0.059 sulphur, 1.69 nickel, 0.16 chromium, 0.46 molybdenum, and 0.15% copper. The chromium and copper were residuals in the scrap.

One of the crankshafts was cooled to room temperature in the mold; the other was shaken out of the mold when it reached 1600 F and cooled in still air to room temperature. Four kinds of heat-treatment were given as follows:

(1) Heat slowly to 1600 F, hold 2 hr., quench in oil, reheat to 1050 F for 2 hr. and cool in air; (2) heat slowly to 1600 F, hold 2 hr., oil quench to 900 F, hold at 900 F 16 hr., cool in air; (3) heat slowly to 1600 F, hold 2 hr., oil quench to 650 F, hold at 650 F for 16 hr., cool in air; and (4) cool in mold to 1600 F, strip from mold and air cool, then stress relieve at 1050 F.

The conclusions reached are that heat treatment to obtain high tensile strength does not give a proportionate increase in endurance limit, thus confirming Moore and Picco. The normal harden-and-temper heat treatment to attain high tensile strength does not necessarily produce any increase in endurance limit; in fact, it may be lowered.

The original as-cast structure has a profound influence on the endurance limit obtained after heat treatment. Unfavorable structures in which the combined carbon is segregated apparently can give a lower endurance limit than the original as-cast condition.

The nickel-chromium-molybdenum gray irons with but little free cementite can be heat treated to an acicular structure with an increase in endurance limit, but the increase is not in proportion to that of the tensile strength.

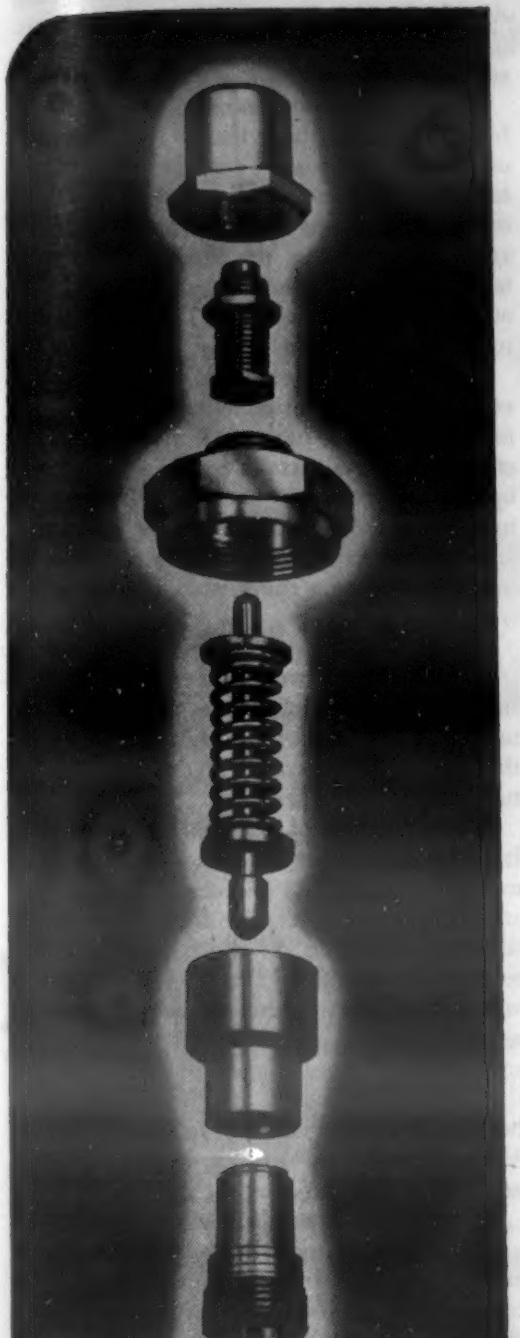
—T. E. Eagan. *Am. Foundryman*, Vol. 8, Dec. 1945, pp. 44-53.

Fracture of Metals

Condensed from "Journal of Applied Physics"

An understanding of the fracture of metals might lead to an increase in the strength level to which metals may be raised without danger of fracture.

Ludwig was the first to recognize that the stress at fracture of ductile metals is the fracture stress not of the original metal but of the metal after having suffered considerable strain. The concept of virtual fracture stress, or the tensile stress necessary to fracture if further plastic deformation does not occur, was then introduced.



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It would be desirable to know the effects of strain, strain rate, temperature, stress distribution, structure, and mechanical history (i.e. fatigue) on the virtual fracture stress.

A relatively simple method is available for estimating the virtual fracture stress of all metals which are ductile at room temperature but brittle at low temperatures. Specimens are deformed various amounts at room temperature, then the temperature is lowered so they break without further deformation. The virtual fracture stress may be highly anisotropic.

There is some evidence that the transverse stress associated with constraints (as in the notched bar test) has much less effect upon the virtual fracture stress than upon the flow stress; therefore, brittle fractures without deformation are likely to be obtained in such tests. The influence of biaxial tension on the virtual fracture stress is not clear.

The virtual fracture stress does not increase as rapidly with decreasing temperature as does the flow stress, so brittle fractures are apt to occur. At high temperatures, there may be a decrease of the virtual fracture stress with time.

A comparison of the fracture characteristics of metallic crystals and those of nonmetallic crystals is needed. The actual strength of crystals is lower than the strength computed on the basis of the interatomic force by at least twice. The only way to reconcile the divergence is to assume localized regions with much higher stresses than the average applied stress. In the case of rock salt, the discrepancy may be accounted for entirely in terms of surface notches, but this explanation would not cover well prepared metal specimens.

Information is needed on the hindrances to plastic deformation by sharp stress gradients and the introduction of stress concentrations by non-metallic inclusions, precipitates, slip bands, twin bands and grain boundary deformation. An initially random distribution of micro-cracks may become highly anisotropic upon deformation. For certain purposes, non-metallic inclusions may be micro-cracks responsible for fracture, but the matrix must also contain origins for stress concentration.

The amount of stress concentration due to precipitated particles will depend upon their shape and size. Stress concentration is also introduced into the matrix by the very fact of plastic deformation. It is believed that viscous slip at the grain boundaries may cause stress concentration and premature fracture.

In fatigue tests there is an area of high stress concentration near the ends of the slip bands. The dimensions of this area are comparable to the width of the slip band. Cracks will not propagate outside this area as they are too small to be propagated by the applied stress. But, successive alterations of stress will increase the width of the slip band and hence the length of the cracks in the areas of high stress concentration at the edges of the slip bands. When the cracks become long enough, the specimen fractures. Therefore, the progress of fatigue is intimately associated with the residual stresses along the slip bands.

—J. H. Holloman & C. Zener.
J. Applied Physics, Vol. 17,
Feb. 1946, pp. 82-90.

NONMETALLIC MATERIALS

Design-uses of plastics, plywood, fibre, glass, rubber, ceramics, etc. as engineering materials. Composite metal-nonmetal combinations. New forms of nonmetallic materials.

Trends in Plastics

Condensed from "The Engineers' Digest"

The wartime developments in organic plastics have been marked by improvements in existing materials and methods, and the establishment of entirely new materials and fields of activities.

Demands for high-impact-strength phenolics brought forth, among others, cord filled and sisael fabric filled varieties. Also, powdered metals came into prominence. Among the new cast phenolics there were introduced some quick curing resins capable of forming large blocks that could be used for tipping cutting tools.

In the field of adhesives, high and low temperature setting phenolics were developed to fulfil the demands of the plywood molding field. Most noteworthy was the wide acceptance of resorcinol-formaldehyde as a boil proof bonding agent.

The superior performance of melamine formaldehyde resins as an arc resisting material led to their wide scale application to ignition distributor housings for high altitude aircraft. Chief interest in the water soluble urea and melamine formaldehyde resins centered upon the adaptation of these materials to increasing the wet strength of paper. Strip-coatings, developed from cellulose acetate-butyrate and from ethyl cellulose, were applied to delicate tool or machine parts from a hot-melt tank. Polyvinyl butyral was used as a water-proofing material for woven textile goods, and polyvinyl chloride-acetate copolymer sheet found its way into many instruments and into computing panels.

High temperature resistant modified polystyrene compounds indicate the introduction of polystyrene as a molding material capable of taking boiling water. Styrene as a new material for the production of butadrine-styrene copolymer was the outstanding synthetic rubber development.

Most obvious machine improvements were in the molding field where the new developments in preheating methods have been particularly outstanding. Latest designs in compression molding presses reflect the trends toward transfer molding. Production machines have also been developed for the blow molding of thermoplastic materials.

A number of new plastic materials made their appearance. Polyesters, or unsaturated alkyds (liquid and paste-like thermosetting materials) are used in the manufacture of transparent thermosetting sheets and in the production of low pressure or contact pressure laminates. Silicones are outstanding as temperature resisting materials. They have made notable contributions as binders for glass fabric.

The applications of polyethylene, particularly as electrical insulation, has been growing rapidly. Furanes (low viscosity liquid resins), produced from furfural and furfuryl alcohol, are highly valuable as adhesives for organic plastics and rubber products. They also serve as liquid resin impregnants and are useful in the application to plaster of Paris patterns and forms.

New fields of activity for the organic plastics include the post-forming of thermosetting laminates. This method extends the possibilities of phenolic laminates from flat or tubular stock to include many curved shapes. Decorative plywoods are prepared through the inclusion of high strength papers or colored prints on the face of conventional plywood.

The techniques of low pressure molding and laminating have formed a new phase of plastics activity, and an entirely new activity has commenced in the resin impregnation of finished plaster of Paris forms or patterns. New high strength adhesives have made possible the preparation of composite laminates of sheet metal to various woods and plastics or other combinations of materials which will increase the fields of application of plastics from a decorative and utilitarian point of view.

—John Delmonte. *Engineers' Digest* (British), Vol. 7, Feb. 1946, pp. 47-50.

The Vinyl Plastics

Condensed from "Purchasing"

The "vinyls" are undoubtedly the most versatile of the plastics. They also have durability and serviceability, to which may be added color to enhance attractiveness. Among many uses for consumers' and industrial goods they offer excellent adhesives for use on practically all types of materials (such as bonding glass to plastic, or plastic to metal, or woods, papers, textiles, etc.). On sheet metal the coatings will not rupture or crack in spinning, drawing or stamping.

The vinyls are available as rigid sheets, flexible sheets, molding compounds for extruding or use in either injection or compression molding equipment, as elastic materials, filaments and fabrics, and in any color, transparent, translucent or opaque.

There are five members of the group: (1) vinyl chloride acetate, (2) vinyl acetate, (3) vinyl butyrals, (4) vinyl chloride, and (5) vinylidene chloride polymers. There are at least eight large and prominent companies that make vinyl plastics.

Polyvinyl chloride, particularly the unplasticized material, had a wide application in Germany for injection molding. In German chemical process industry it replaced stainless steel for piping, valves and vessels. Plasticized material was used widely in bristles, sheets and foil.

Among the outstanding characteristics of the vinylidene chlorides are resistance to chemicals and solvents, their very low water absorption rate, their nonflammability and their nonaging qualities. A practical thermoplastic pipe has been on the market for some time; it weighs one-quarter as much as the comparable sizes of steel pipe. It is used in chemical and petroleum plants and for disposal lines to carry off waste corrosive acids. In the electrical power field it is used on heat exchangers and rectifying units. Pickling solutions have no effect on it. It is threaded with standard tools, and can be easily "welded" on the job.

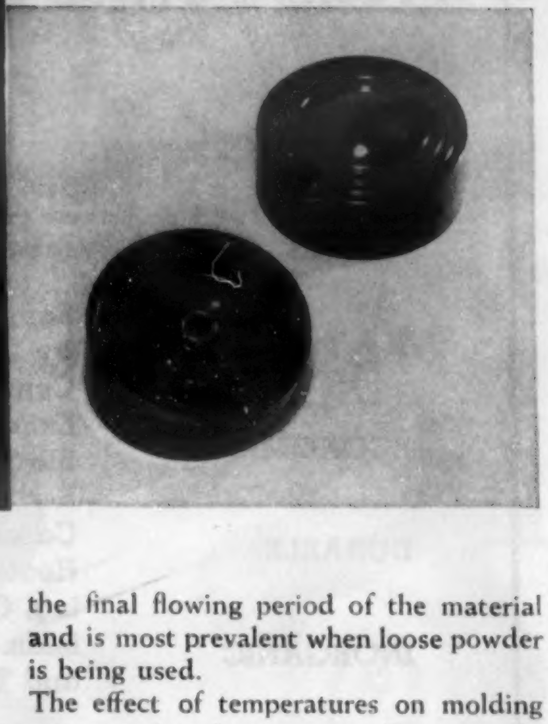
Vinyl rigid sheets may be formed and shaped under heat and can be drawn to a depth two or three times the size of the original. The sheets may be blown, spun, swaged or formed around a mandrel into complicated 3-dimensional shapes; they may be punched, sawed or sheared.

By the use of plasticizers, flexible molding and extrusion compounds are produced. They may be injection or compression molded. The elastomeric compounds may be extruded around wire or cable to provide excellent electric insulation. Another group is suitable for industrial fabrics, such as filtering cloths, pressed felts and sewing threads and twines. The polyvinyl butyral resins are used as the interlayer material in high test safety glass and as coatings and adhesives.

The polyvinyl chloride resin is used principally for flexible tubings, extruded cable coatings, gaskets and washers. Outstanding among the properties of these resins are

ENGINEERING DATA ON PLASTICS

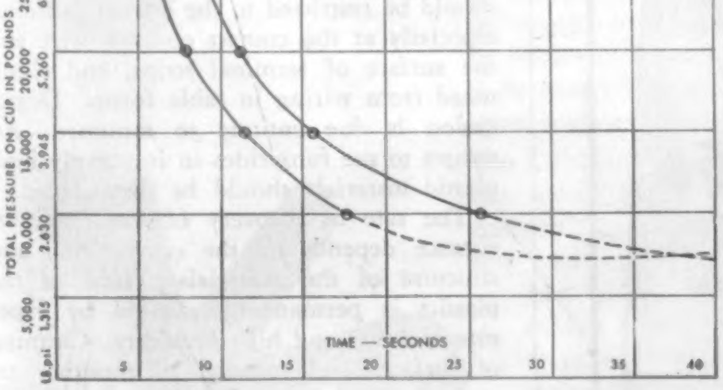
3. PHENOLIC MOLDING TEMPERATURES



The following methods of mold or platen heating are used in the plastics industry: (1) steam, (2) electricity, (3) gas, (4) hot oil, and (5) hot water. All of these may be employed satisfactorily. However, saturated steam is generally preferred due to the latent heat of condensation and the simplicity of adjustment for various temperatures. Although hot water is the most economical, it presents several difficulties.

Mold Temperatures

Mold temperatures depend upon the material being molded, the design and thickness of the part, method of molding, and molding pressures. Generally the temperature range for phenolics is from 280°F. to 350°F. However, temperatures up to 375°F. are being used, particularly on thin, uniform section parts such as closures.



The lower range of temperatures is recommended for mineral-filled materials, particularly mica-filled which is temperature sensitive and of short flow duration. Lower temperatures are also desirable in compression molding parts with long flow, to prevent the material from setting up, particularly where there is a possibility of extending the mold closing time above 30 seconds.

Furthermore, heavy sections often require lower temperatures, especially on fast-curing materials, to eliminate the possibilities of case-hardening the outer surface.

The effect of various temperatures on curing time is quite evident. In checking the curing time of a general-purpose material, using electrically heated automatic press on the part illustrated, the following results were obtained: 320°F. 67 seconds, 350°F. 52 seconds, and 370°F. 33 seconds. The surface appearance at high temperatures is somewhat inferior to that of parts molded at 320°F. and 350°F.

Temperatures over 350°F. are not recommended for parts having bosses and ribs, for these designs often create "dead end flow," causing a staining of the mold at these particular points. This is caused by the lack of wiping action during the final flowing period of the material and is most prevalent when loose powder is being used.

The effect of temperatures on molding pressures is quite apparent. For example, in molding a general-purpose material at 325°F. and producing satisfactory parts at 3945 psi. the test cup mold will close in 15.4 seconds. Increasing the temperature to 350°F., it will require 17.6 seconds to close the mold at 2630 psi. Hence it is possible to operate the equipment at lower pressure or possibly mold a greater area in the same tonnage press and also save considerable time in curing.

The curve chart illustrates the difference in mobility between mold temperatures of 320°F. and 350°F.

If the mold temperature is too high, the following difficulties will be encountered: (1) molded pieces sticking to the mold surface, (2) dull surface, (3) case-hardening the outer surface, (4) thick fin, (5) sunken surface caused by the material setting up on the land area, (6) staining of the mold, and (7) blistering due to case-hardening.

If the mold temperature is too low, the following difficulties will be encountered: (1) molded pieces sticking to the mold surface, (2) blistering due to undercure, (3) warped pieces upon ejection, (4) ejector pins piercing through due to insufficient rigidity, (5) poor mechanically, and poor chemical resistance, and (6) poor production efficiency. Durez Plastics & Chemicals, Inc., 95 Walck Rd., N. Tonawanda, New York.

DUREZ

PHENOLIC RESINS

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PLASTICS THAT FIT THE JOB

their unusual chemical inertness and resistance to corrosion. One of the series is good for plating rack and tank linings.

—G. E. Henry. *Purchasing*, Vol. 20, Feb. 1946, pp. 115-119.

Effects of Humidity and Fungi

Condensed from "The ASTM Bulletin"

Experiments were begun two years ago to determine the decrease in insulation resistance of methyl methacrylate, glass-bonded mica, glass mat laminate phenolic, phenol fabric, phenol fiber, and wood-flour-filled phenol plastic during prolonged exposure of the plastics to fungi and 97% relative humidity at 25 C. The same plastics with fungi present are exposed also to 87, 76, and 52% relative humidity to study their recovery, and then re-exposed to 97% relative humidity.

Samples with cleaned surfaces and with varnished surfaces were dried and then exposed to fungi and high humidity. The insulation resistance to the formation of a fungus network on methyl methacrylate is determined at 87, 76, and 52% relative humidity.

Fungus growth occurred on all the test specimens except those with cleaned or varnished surfaces. The insulation resistance may be so rapidly affected by water adsorption or condensation, that any further adverse effect by fungus growth is negligible. Measurements of the insulation resistance of a piece of stock methyl methacrylate show that condensed water will cause an immediate reduction. If condensation occurs on a plastic which neither absorbs nor is wetted by water, it is found that when the surface is contaminated by water absorbing alien material there is a greater ultimate effect on insulation resistance.

The decrease in insulation resistance is retarded by varnish. Use of the varnish should be restricted to the critical portions, especially at the contact ends of wire and the surface of terminal strips, and eliminated from wiring in cable forms. Degradation is due entirely to moisture. Attempts to use fungicides in inherently inert plastic materials should be discouraged.

The rate of recovery of insulation resistance depends on the composition and structure of the materials. None of the plastics is permanently affected by exposure to fungi and high humidity. Cleaning of surfaces and removal of moisture restore the insulation resistance to its original high value in every case.

Water adsorption and absorption, not fungi, are the critical factors in the deterioration of the insulation resistance of these plastics. Maximum operating life of equipment under adverse conditions can be insured by selected insulating materials that adsorb and absorb the least water; using thoroughly dried, hermetically sealed apparatus on components; designing equipment with heaters; and proper design, packaging, storage, and maintenance.

—John Leutritz, Jr. & D. B. Herrmann. *ASTM Bulletin*, No. 138, Jan. 1946, pp. 25-32.


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A National Cash Register is built for hard wear. It is designed to stand up to the punishment of fast starts and quick stops, and may record as many as 30 million sales in the course of its lifetime! That is why the best engineering skills and the finest materials must go into the manufacture of these modern machines.
The Celanese plastic items shown on this page are working parts of National products, both cash registers and accounting machines. They are manufactured in several different ways, and full advantage is taken of the qualities of the material and the benefits possible in plastics production. Some are injection molded in multiple cavity molds, others compression molded. Fabricating methods to produce the finished parts include laminating, machining, cementing and inking of recessed lettering.
In your product planning, the advice of our technical service staff may indicate how and where you can use plastics most effectively. The war experience of Celanese plastics can give you new insight into what these materials can do in improving products and reducing costs. Celanese Plastics Corporation, a division of Celanese Corporation of America, 180 Madison Avenue, New York 16, N. Y. *Reg. U.S. Pat. Off.
LUMARITH*
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VIMLITE* Plastic Glazing
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GENERAL PRODUCT DESIGN

Selection, applications and design of parts made by various fabricating methods or made of special materials. Properties and uses of finishes and coatings. Design and materials for specific products or fields. General engineering design trends or principles.

Wartime Materials

Condensed from "The ASTM Bulletin"

Contrary to the expectations of the average individual, new developments are appearing on the market much slower than had been anticipated. Advertisements have over-emphasized these new products. However, many improvements have been made in materials and methods.

The gas turbine has been known for years, but has only recently become practical because of the development of special temperature-resistant alloys for turbine buckets and nozzles.

Very superior magnesium, aluminum, steel and bronze castings have been made during the war as a result of careful studies of the casting process from the melting of the metal through heat treatment. The lost-wax process is also now used extensively as the result of research, in the production of wear- and heat-resistant metal parts which are extremely difficult to machine.

Research was conducted on the deformation characteristics of the stronger aluminum alloys and methods of forming these alloys. Unique forming methods were developed which permitted large scale production of aircraft parts, at the same time permitting rapid modifications for new designs.

The development of the helium-arc-welding process has been an outstanding wartime innovation in magnesium technology. In this process, helium gas is flushed past the electric arc to form an inert atmosphere around the molten metal at the weld.

Magnesium alloys have found applications in aircraft landing wheels. Cast magnesium wheels have now been successfully developed for automobiles and can withstand rugged service.

Glass research has resulted in flameproof, rot-proof, vermin-proof, and stronger cloth made of glass fibers spun into threads. Layers of glass cloth impregnated with a thermosetting resin have produced laminates successfully used as body armor for combat troops.

Many new plastic materials were developed during the war. The silicone resins represent a totally new approach to the electric industry by permitting use of unusually small, high-output motors operating at temperatures above those possible with usual insulation. The plastics industry is still in its infancy, and the position of this group in the materials field will be greatly enhanced in the years to come.

In the textile fiber field nylon has found many applications during the war, and will be just as applicable during peace time. High-tenacity rayon will continue to be used in truck tires and high stress uses. Synthetic rubber developments will have many civilian applications in items such as foamed latex sponge, rubber springs for automobiles, protective coatings, packaging, and tires.

Impregnation of wood with synthetic resins has increased strength, moisture resistance, and dimensional stability without an undue rise in density. Use of synthetic-resin glues has aided the development and use of laminated wood construction.

Science and technology may rightfully be considered a vital national resource, for it is research on the naturally occurring resources that prolongs their use and prevents depletion.

—J. C. DeHaven. *ASTM Bulletin*, No. 138, Jan. 1946, pp. 17-24.

Designing Welded Machinery Parts

Condensed from "The Welding Journal"

At least 12 different types of components can be utilized by a designer in his weldment and each of these components can be used in several ways. This discussion is limited to dynamically-loaded, welded machinery parts. Hot-rolled steel plate probably is the most universal component used in such structures. Flame cutting is the common method of shaping and sizing components.

The more generous the tolerances on components, the more prevalent are gaps in fitting. Gaps require the deposition of a greater amount of weld metal, increasing costs and destroying the metal-to-metal contact which resists tendencies to shrink and warp.

Design sometimes dictates prefabrication machining, one reason for which is the provision of economical welding kerfs in combination with good joint fit-up, particularly in welding thick plates. A kerf must provide sufficient width to clear the tip of the welding electrode to permit the depositing of weld metal at the root of the weld. It is also necessary in case of conflicting tolerances in the fitting of circular components within each other.

Another method for shaping plate components is blanking or punching on a power press. A simple example is the shearing of a rectangular plate. By blanking the piece, only one operation is needed against four needed in shearing.

Besides the flat pieces, one must consider "formed" components. One method is press bending to make horizontal angular bends, which eliminate one or more welded joints. Another method is fluing, flued openings, for instance, providing formed seats for covers. Fluing often eliminates assembly, welding and consequent warpage and cost of drilled and tapped holes, making, too, for weight reduction.

When quantities justify, formed components produced in special shapes by forming dies on power presses may be used advantageously. Shapes formed on a rolling mill are often valuable because of the reduction in cost due to elimination of welding and the resulting warpage.

Steel castings are used where economical in producing complicated shape requirements or where special contours at given points in a particular assembly are involved. Electric furnace steel castings are preferable because of greater cleanliness.

As to fabrication, there are two important aspects. The first involves the extent to which positioning facilities, automatic welding units, inspection methods and stress-relieving facilities are employed. The second involves special jigs or fixtures or other types of tooling that might be justified or imperative. If the product is very repetitive, possibilities in special tooling should

DESIGNING for DIE CASTING

LETTERING

In designing die castings, keep in mind that lettering, numerals, trade marks, diagrams or instructions can be cast on the surfaces.

Raised, rather than debossed engraving should be specified, since it is less costly to cut a design *into* a die than to make a raised design *on* the die surface. If, however, the engraving cannot project above the surface of a casting, debossed engraving can be achieved by using raised engraving on a removable panel set into the die.

The electric meter adapter box shown here is an excellent example of the utilization of engraving on a zinc alloy die casting. A wiring diagram has been cast on the interior—and lettering on the exterior—of this casting. The two surfaces on which the raised engraving appears are parallel to the die parting and, therefore, the engraving does not interfere with ejection of the casting from the die.

Additional data on engraving will be found in our booklet "Designing For Die Casting." To insure that you will get the most from your die casting dollar, ask us—or your die casting source—for a copy of this booklet.

The New Jersey Zinc Company, 160 Front St., New York 7, N.Y.

ZINC
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The Research was done, the Alloys were developed, and most Die Castings are based on
HORSE HEAD SPECIAL (99.99+% Uniform Quality) ZINC

be considered. Also to be weighed is the breaking up of the weldment into subassemblies.

—G. L. Snyder. *Welding J.*, Vol. 25, Feb. 1946, pp. 105-118.

Sintered vs. Cast Parts

Condensed from "Product Engineering"

Sintered metals are customarily divided into two groups: (1) those which can be produced by other methods as well as by powder metallurgy; and (2) those which can be produced only by powder metallurgy. In spite of the cost of metal powders, savings can be shown in many cases by the use of sintered products of group (1). The prevention of scrap losses may make these products competitive with those produced by machining bar stock. Group (2) includes sintered carbides, contact materials, high melting point refractory metals, porous parts, metal-nonmetallic composites and parts made of non-alloyable metals; many of these products are not finished by powder metallurgy.

The borderline between these groups is not rigid. If definite advantages are found for the products made by powder metallurgy, the product may shift from group (1) to (2) (non-equilibrium copper nickel alloys and tantalum are examples).

Comparative properties are given for silver, gold, platinum, nickel, cobalt, copper, iron and carbon steels made by powder metallurgy and by other methods. Sintered products in some cases are still definitely inferior; in other cases, the properties of the sintered products closely approach those of the cast and wrought articles. Advances in the control of powder metallurgy processing will enable advances in engineering characteristics of sintered products so that in many cases they will be superior to competitive products.

The future development of powder metallurgy will depend to a large extent on the price of metal powders. It is expected that the price will decrease as the amount used increases. Therefore, more and more sintered articles will become competitive with parts made from bar stock.

Even where the strength of cast or wrought alloys is superior to that of the equivalent sintered alloys, the latter may still be satisfactory for applications that do not require the maximum strength and ductility. In many cases, the engineering properties of sintered and subsequently worked parts are already superior to those of cast material similarly worked.

However, any method of working other than re-pressing necessitates abandonment of the close tolerances of the sintered parts. Hot pressing and hot re-pressing will also give similar properties along with precise dimensions.

Where the properties of sintered materials are still inferior, the cause is mainly porosity which reduces strength and particularly ductility, not only by the reduction in effective cross section but also by a notch effect. Porosity can be eliminated by conventional working after sintering or by hot re-pressing.

—Paul Schwarzkopf. *Product Engineering*, Vol. 27, Feb. 1946, pp. 122-126.

Advertisement MAY, 1946

COPPER ALLOY BULLETIN

REPORTING NEWS AND TECHNICAL DEVELOPMENTS OF COPPER AND COPPER-BASE ALLOYS

Prepared Each Month by Bridgeport Brass Co. "BRASS Bridgeport CO." *Headquarters for BRASS, BRONZE and COPPER*

Copper-Base Alloys

Effect of Additional Elements on Physical Properties and Corrosion Resistance

When copper is alloyed with zinc in various proportions, the resulting material is known as "brass" which is stronger than either of the materials from which it is made. In general, the physical properties of brass depend largely upon manipulation, that is, whether it has been cast, rolled, extruded, drawn, or annealed. Properties such as ductility, springiness, toughness, strength, and stiffness are controlled either by annealing or by the amount of reduction by cold rolling or drawing following the last anneal. Machinability, corrosion resistance, hot and cold workability, etc., are controlled largely by modifying the proportions of copper and zinc, and by the addition of small quantities of elements such as lead, tin, silicon, aluminum, nickel, phosphorus, arsenic, etc.

Electric Furnace Melting

Bridgeport quality begins in the casting shop where melting and alloying are performed in the types of electric furnaces suitable for the particular alloys involved. At a turn of the wheel the furnace is tilted and its contents are poured into the immense water-cooled copper-lined mold to make a cast bar. Although the oldtime hand-fed pit fires were spectacular, melting in electric furnaces has been among the most important advances to improve materially the uniformity and quality of present-day brass mill products.

A casting in the form of a flat bar is the starting point for sheet and in the form of round billets for rod, wire and tubing. Samples taken at the furnace during pouring are speeded to the laboratory for analysis to make sure that all alloys are controlled within specifications. Impurities which may affect the uniformity of the product are checked by frequent spectrographic and chemical analyses. The laboratory takes a most important role in brass making—analyzing incoming raw materials, specifying the mill treatment to meet customers' requirements, checking the finished material, developing better processes, creating new alloys, and improving existing ones.

The Copper-Zinc Alloy System

When copper and zinc are melted together they alloy to form a new material, brass, which is quite different from the parent metals. As the copper content decreases, the brasses vary in color from rich bronze (90-10), to golden (85-15), to yellow (70-30) and finally yellow-red (60% copper, 40% zinc).

Roughly, alloys containing from 63% to 100% copper are of the alpha type and are suitable for cold working such as cupping, drawing, stamping, cold forging. Strip metal for drawing and stamping and wire for cold heading come under this range of composition. Alloys in the low copper range (60 ± 2% copper, remainder zinc) are best suited for hot extrusion and hot forging and have the characteristic alpha plus beta type structure. Brasses below 58% copper have a limited application.

Effect of Additional Elements

There are many important brass and copper alloys which have been modified or whose properties have been changed by the addition of a third or fourth element. In every case the added element has been selected because of some specific improvements desired. With the growth of modern science and the development of metallurgical laboratories, the effect of various additions has received very careful study. One of the major research problems in the brass industry today is the thorough and systematic study of the effect of additions and the search for those additions that will provide specific improvements.

Lead added to brass in amounts ranging from 0.15% to 4% greatly improves its machinability. There are limitations on the amount of lead to be added because of its harmful effect on ductility and cold and hot forgeability.

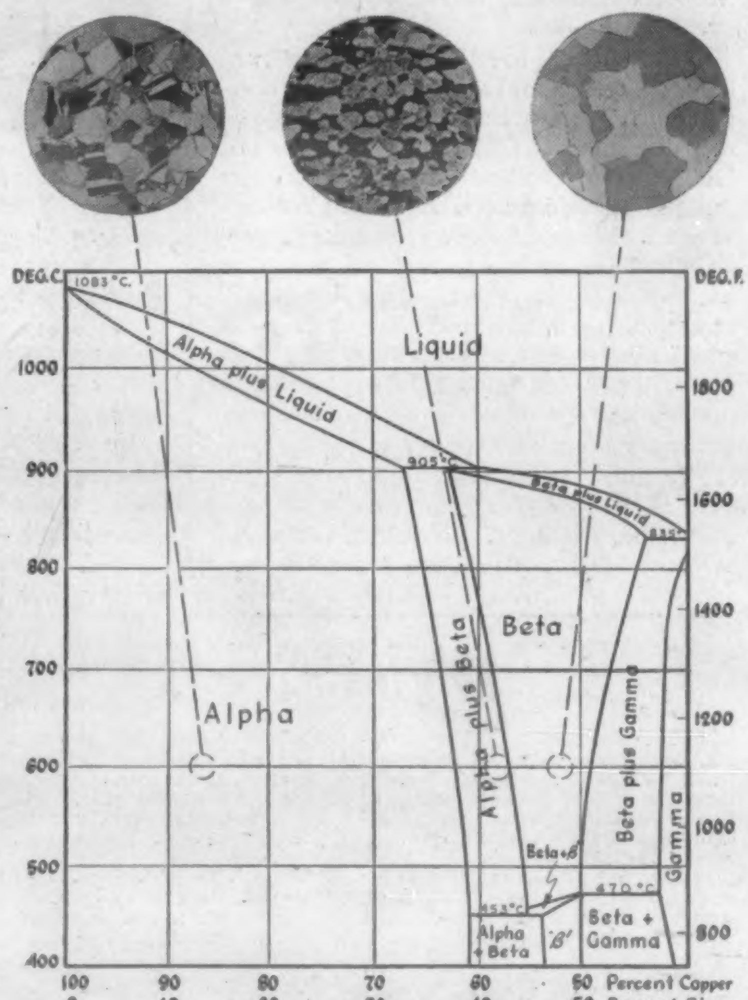
Tin is added to brass in amounts up to 2%. The addition of 0.75% to 1% improves its resistance to corrosion from sea water. For example, Admiralty condenser tubes contain copper 70%, tin about 1%, zinc remainder. Tin added to 60-40 brass is designated as naval brass (copper 60%, tin .75%, zinc remainder). Tin added to the high copper-zinc alloys increases strength and modifies the color. Such alloys are popular with the jewelry trade.

Aluminum is added to brass to improve its resistance to impingement corrosion from turbulent water, containing entrapped air, flowing at high velocity. Aluminum brass condenser tubes contain approximately copper 76%, aluminum 2%, and remainder zinc. Aluminum also increases the strength of brass and is often one of the minor elements in manganese bronze, a 60-40 brass which contains small amounts of manganese, iron, tin and aluminum.

Silicon—A small percentage in brass lowers its thermal and electric conductivity and makes it suitable for spot welding. A very small quantity of silicon in bronze welding rod has the effect of reducing the fuming during welding. Silicon in amounts up to 3% added to copper increases its strength and toughness. Copper-silicon alloys are sold under the trade names Duronze I, II and V. Silicon added to aluminum bronze increases its strength, corrosion resistance and machinability. Just as in brass, silicon affects the alpha-beta phase boundary relationship. Hence, a normal alpha structure may be thrown into the alpha plus beta structure with correspondingly better hot working properties.

Iron increases the strength and hardness of brass and is sometimes added in the Muntz metal type of alloy. It retards grain growth during annealing. Standard specifications for brass strip for cupping or drawing limit the permissible iron content which is not considered desirable when maximum ductility is required.

(Continued on back page)



COPPER-ZINC DIAGRAM

COPPER ALLOY BULLETIN

Copper-Base Alloys (Cont.)

Nickel additions to copper-zinc alloys have been made for many years, the resulting alloys having been known as nickel silver. The addition of nickel whitens brass until it becomes silver in color. As the nickel content increases, the alloy becomes stronger. The alloy containing 18% nickel is commonly used as a base for silver plated hollow ware. Nickel greatly lowers the electrical conductivity of the alloys and makes them desirable for high resistance purposes.

Arsenic, phosphorus and antimony, acting as corrosion inhibitors, are added in small amounts to brass condenser tube alloys to increase their resistance to dezincification from sea water.

Research and Development

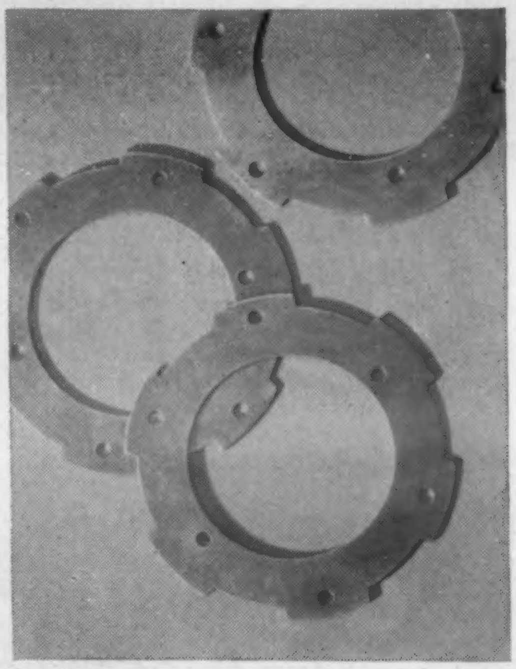
Intensive research and development of copper-base alloys in the last decade have completely changed the picture for brasses and bronzes. Many new alloys and improved old ones are resulting from the work done by Bridgeport metallurgists. This work has been stepped up considerably during the past few years. Also a consistent program of corrosion research has brought forth much new information regarding the behavior of metals in corrosive media. As a result our Technical Service Department is better equipped to help fabricators of metal goods with their problems. We are also in a better position to collaborate with engineers of power plants, oil refineries, and chemical industries to increase the service life of condenser, heat exchanger and evaporator tubes.

Continued improvement in the quality of basic materials makes possible lower costs through the reduction of scrap losses and extra mechanical and finishing operations. Nevertheless, the limitations of each alloy must be taken into consideration. Laboratory supervision, however, has made possible uniform control of such properties as hardness, softness, machinability and grain structure. Once the fabricator determines which properties fit his methods of manufacture, the mill is then in a position to furnish uniform material and reduce unnecessary labor and spoilage.

For more complete details on copper-base alloys write for your copy of Bridgeport Brass Technical Handbook. 128 pages of practical data.

Bridgeport's Phosphor Bronze for Starter Clutch Discs

Bridgeport's Phosphor Bronze, improved through advanced processing and quality control methods, has found wide use in aircraft starter clutch discs because of its excellent resistance to fatigue and wear, as well as the accuracy of its manufacture. The clutch is built up of alternate discs of bronze and steel, and any surface imperfections or temper differences would mean excessive wear and slippery, unreliable clutch action.



Aircraft motor starter clutch discs made from Bridgeport's Phosphor Bronze

The Phosphor Bronze for these motor starter clutch discs is produced to very close limits of surface variation and allows perfect contact between the steel and bronze discs over the entire area of all surfaces. Since the ratio with respect to variation in temper between the two materials determines the amount of wear, the hardness of Bridgeport Phosphor Bronze is carefully controlled. Its dependability in such engineering applications is the result of precision manufacture, which maintains its exceptional physical properties at a consistent level of quality.

NEW DEVELOPMENTS

This column lists items manufactured or developed by many different sources. None of these items has been tested or is endorsed by the Bridgeport Brass Company. We will gladly refer readers to the manufacturer or other sources for further information.

New Height Gage for the precision inspection, layout, scribing and checking of large size jigs, fixtures, dies and castings employs an extra large vernier permitting finely graduated scales to be read quickly, easily and more accurately. It is furnished in various sizes provided with both English and metric scales. **No. 681**

Portable Spot Welding machine has been announced which has a capacity for parts under 1/8" round. Weighing approximately 25 pounds, the unit employs a pair of insulated copper tweezers which eliminate oxidation and enable the electrodes to be applied directly to the elements to be joined. It plugs into 115 V, 60 cycle power supply and may easily be adapted to 220 V. **No. 682**

Automatic Cut-off for the completely automatic manufacture of return bends or elbows is capable of handling tubing up to 5" O.D. and pipe up to 4" O.D. **No. 683**

New Surface Preparation has been developed for use on copper, brass and zinc products where shot or sand blasting are impractical prior to application of protective coatings. **No. 684**

Filing, Sawing, Lapping and trimming operations are achieved with a new, all-purpose die filer machine. It has few moving parts and filing and sawing overarms may be interchanged in a short time. **No. 685**

New Automatic Flow regulator for use with hydraulic machine tools offers unlimited flow in one direction and predetermined rate of flow in opposite direction. **No. 686**

High-speed Lathe for bench work is used for finishing and polishing small metallic and non-metallic parts. Permits a range of working speeds from zero to 40,000 RPM and can be detached and used separately as a hand tool. **No. 687**

In a Quenching Machine for gears, liners, bearing races and discs, work is held by air pressure between upper and lower dies while quenching oil is pumped from below at timed rates to pass upward through the lower die, surround the work and leave through the upper die. Machine is said to prevent distortion in the work, controlling application of the oil. **No. 688**

Roller and Ball Bearings in guide pins of new die sets are reported to eliminate the possibility of their "freezing" even at high speeds. Die sets can be opened and closed by hand. Round pin die sets use ball bearings and square pin models use roller bearings. **No. 689**

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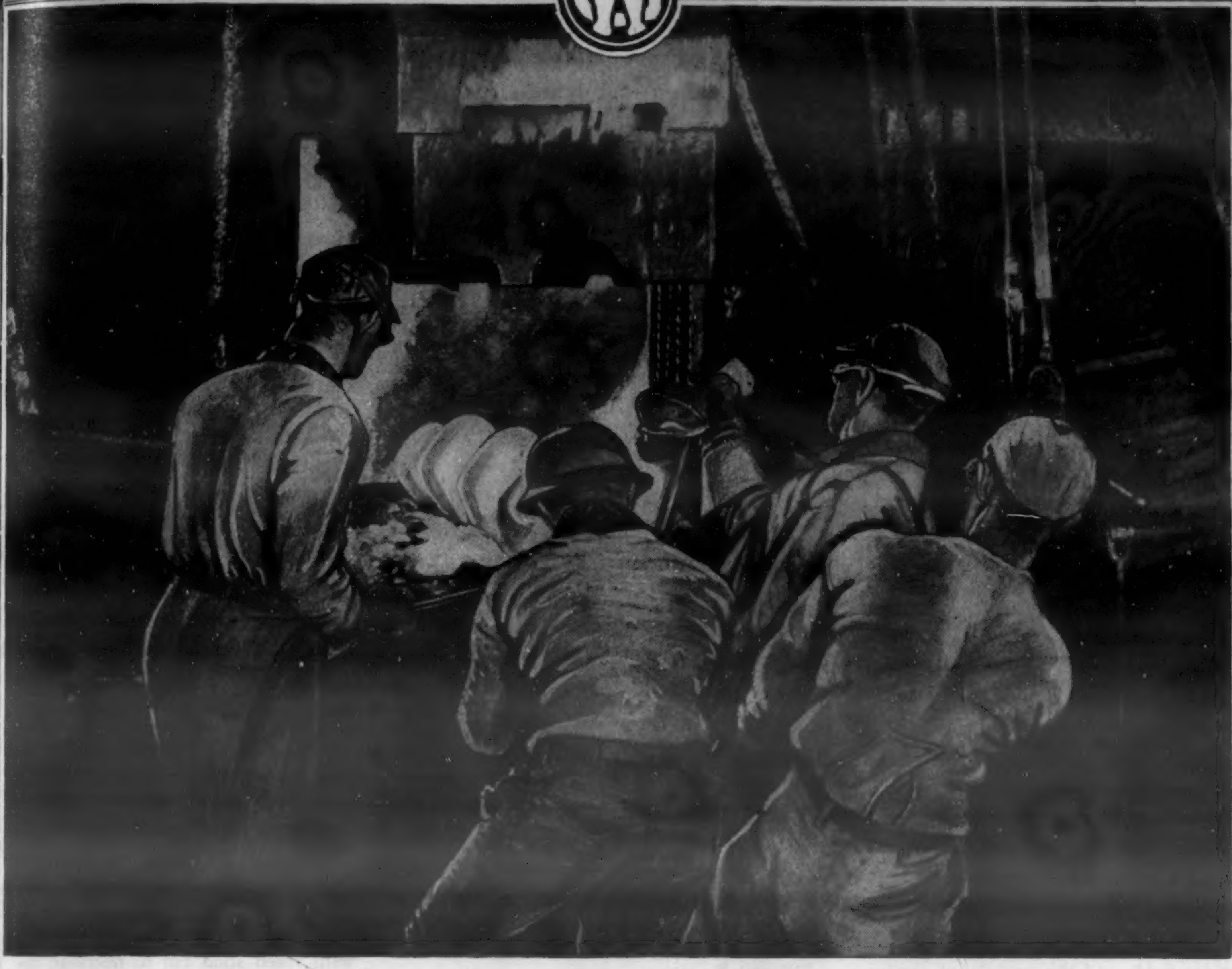

MELTING and CASTING

Melting, alloying, refining and casting methods, furnaces and machines. Iron and steel making, nonferrous metal production, foundry practice and equipment. Die casting, permanent mold casting, precision casting, etc. Refractories, control equipment and accessories for melting furnaces.

Casting Magnesium

Condensed from "Western Machinery & Steel World"

Magnesium has been used as a structural metal for the past quarter of a century. As with most other metals, casting is the simplest and oldest method of producing magnesium shapes. Research work done during the past 25 years has added sufficient knowledge to the techniques to permit magnesium to be cast safely in green sand, dry sand, core sand and die molds by any foundry that follows certain relatively simple procedures. The physical and mechanical properties of magnesium are such that the metal has found widespread use in various fields and the process of casting is relatively simple.

Molding sand used for magnesium founding is usually an open, sharp sand. For green sand molds, about 4-10% of a "sand addition agent" is added, its function being to prevent a reaction between the molten magnesium and the temper water. The sand is usually reconditioned and re-used after the addition of such amounts of inhibitor and water as are necessary to keep the properties of the sand within the specified limits.

Where exceptionally close tolerances are required on the casting, dry sand molds are used. Sand used for cores should also be a sharp, open sand and the bonding agent may be any good quality core oil, although synthetic resin binders have found increasing favor in recent years because they impart certain desirable properties to the sand, namely high dry strength, and easy collapsability of the core shortly after the casting has been poured.

Wherever possible, the casting should be gated in such a manner that the metal can enter the mold at the lowest point and fill the mold cavity with the greatest speed possible. Perforated skim gates are usually inserted in the ingates to prevent entry of oxides and flux into the casting.

Magnesium alloys must be melted under a protective flux covering to prevent burning. After the metal has been melted, it is superheated to about 1650-1700 F for 15 min. in order to refine the grain. The melt is then cooled down to the pouring temperature of about 1400 F and poured. When cold, the castings are shaken out and cleaned. The clean scrap is combined with ingot, and for remelting the usual ratio in a charge is 70% scrap and 30% ingot.

For maximum toughness and shock resistance, the castings are solution heat treated (10-20 hr. at 700-800 F) and air quenched. If maximum strength is required, the castings are aged 8-16 hr. at 300-400 F after solution treatment. Where dimensional stability is of prime importance, the castings are stabilized 2-6 hr. at 425-550 F.

Heat treating furnace atmospheres usually contain 0.7% sulphur dioxide to prevent surface oxidation; and fast circulation of the atmosphere is of prime importance to control furnace temperatures to a required accuracy of plus or minus 5 F.

Magnesium die castings have found widespread use. An alloy containing 9 aluminum, 0.2 manganese, 0.6% zinc, balance magnesium is most commonly used for die casting. Usual casting pressures range from 4000 to 15000 psi.

The metal is melted in a steel pot under a dome shaped cover containing a quantity of sulphur. Oxidation of the sulphur provides a protective atmosphere of sulphur dioxide. Dies are preheated to a temperature between 250 F and 600 F, and the metal is poured at about 1175 F.

—M. M. Moyle. *Western Machinery & Steel World*, Vol. 36, Dec. 1945, pp. 542-546, 587.

Cupola Operation

Condensed from "American Foundryman"

One of the first requirements for successful cupola operation is an exact knowledge of the composition and behavior of the raw materials making up the charge. The weighing equipment for the charge must be accurate. Long burning in times are preferable. Extra limestone should be used to form a large volume of fluid slag for protecting the molten iron and give a higher melting temperature.

While the percentages of all elements are important, the total carbon content of the melt is of extreme importance. Proper records of the cupola mixtures and operation are invaluable in making up mixtures with predetermined carbon. The carbon pick-up is apt to be less uniform with intermittent tapping than when the metal is removed as fast as it is melted.

An exact tapping cycle must be maintained if the carbon content is to be uniform. If all other things are equal, the total carbon of irons melted with by-product coke is lower than that obtained with pitch or beehive coke. Pitch coke gives the highest carbon content.

Auxiliary cupola equipment plays an important part in the control of the uniformity of the molten iron. Mechanical charging is a help, as is the control of the moisture content of the air used for the blast.

A constant air-weight control blower eliminates the variables of constantly changing atmospheric conditions. Balanced blast cupolas make possible a more efficient cupola operation and melt somewhat faster and at higher temperatures for the same coke ratios than cupolas with conventional tuyeres.

The molten iron is run directly into forehearths or teapot ladles, where it is stored and mixed to give a greater uniformity of metal composition. The metal in the forehearth or teapot ladle is treated with fused soda ash to decrease the sulfur, remove the entrained silicates, increase the fluidity, deoxidize and refine the grain size.

All iron is innoculated with a minimum of 0.2% zirconium silicide; 75% ferrosilicon is also added, as all mixtures are calculated for low silicon. It is very advantageous to be able to pour castings of wide variations in section size from the same base iron by adding varying amounts of silicon. Also, varying amounts of ferrochromium or one of the stabilizing types of innoculant may be added.

In the case of high strength iron for thin walled castings, a double innoculation (addition of both graphitizing and stabilizing types) is used to facilitate machining. Complete chemical and mechanical tests are made at suitable intervals.

A series of patented high quality cast irons are produced. Synthetic pig iron with a maximum of 0.2% phosphorus is made by melting 100% steel scrap or other ferrous materials in the cupola. It is cast in ingots and then remelted in the cupola. By means of proper additions, suitable compositions can be made that are satisfactory for making castings of any metal section.

One of the chief differences between irons made by this method and ordinary cast irons is the use of up to 1.5% zirconium silicide as a ladle innoculant. Even though zirconium silicide is usually considered a graphitizer, the microstructures of these special cast irons show no ferrite.

—W. W. Levi. *Am. Foundryman*, Vol. 9, Feb. 1946, pp. 46-54.

Pyrometry of Liquid Iron and Steel

Condensed from "Iron and Steel Engineer"

The problem, in essence, involves the measurement of temperatures in the range of 2600 to 3100 F with an accuracy of plus or minus 10 deg. The metal is usually covered with slag, which may be highly reactive and will therefore contribute to the early destruction of any equipment immersed in it. This slag also blankets the metal from direct observation with an optical or radiation pyrometer.

The high melting points of tungsten and molybdenum, about 6000 F and 4600 F, respectively, suggested these metals as thermocouple elements for molten steel. However, it was found that because of the necessity of long immersions, the life of the couple was short, and maintenance cost would be high.

The tungsten-graphite thermocouple has several features of interest: (1) It develops an emf of reasonable magnitude—about 3.8 millivolts at 3000 F; (2) good sensitivity—about 1.25 millivolts per hundred deg. at 3000 F; (3) relatively simple design—the graphite protection tube for the tungsten forming the other element; and (4) the reading is only slightly affected by reasonably large changes in cold-junction temperature. Disadvantages include need for protection of the graphite from attack by lower carbon iron or steel, the couple is not rugged, uncertainty of calibrations, and inconvenience of water cooling.

The carbon-silicon carbide thermocouple is quite unusual in that the electromotive force generated at 3000 F is almost one-half a volt. This corresponds to about 17 mv. per 100 deg.

The one element of the thermocouple is a silicon carbide rod set coaxially in a closed-end graphite tube which forms the other element.

The platinum rhodium thermocouple has been used as the standard pyrometer for measuring steel temperatures. It, however, has its disadvantages in that it is fragile, bulky, subject to heat shock, and sluggish. Because of these disadvantages, English metallurgists developed the quick-immersion platinum thermocouple technique. In this case, the platinum is protected from the slag and steel by only a thin quartz tube over the hot junction. An immersion time of 15-30 sec. is considered normal for a satisfactory reading.

Determination of temperature by radiation from a body involves the use of a pickup unit sensitive to these radiations. The optical pyrometer is used to obtain the temperature of an open hearth bath and also for observing the temperature of the steel during tapping and teeming. Dust and smoke interfere with accurate readings.

Because of the emissivity factor in the use of optical pyrometers, two-color pyrometers have been developed. Little data is available on their actual use in the steel mill. Also, photo-electric pyrometers have been developed, but little data is available on their use.

Total radiation pyrometers have been employed extensively for surface measurements of hot solids and for furnace measurement and control, but references to their use for liquid iron and steel are limited.

Another approach to the measurement of bath temperatures is embodied in the open-end tube immersion pyrometer which is being used with both photoelectric cell and total radiation pick-ups.

—H. T. Clark. *Iron & Steel Engr.*, Vol. 23, Feb. 1946, pp. 55-62.

High Frequency Steel Melting

Condensed from "Iron and Steel"

A high-frequency furnace has been installed in the plant of James Neill & Co., Ltd., Sheffield, England, for the production of composite steel ingots. Hematite cast iron ingot molds are used, each of which has fitted in one corner, or across one side, a second smaller mold formed by an angle-shaped removable plate. This loose piece is firmly held in the mold by means of wedges.

Steel containing about 1.25% carbon and varying amounts of alloying elements is first poured into the smaller mold. As soon as this steel solidifies, but while it is still white hot, the removable plate is knocked away and lifted out of the mold. Molten steel containing a maximum of 0.2% carbon is then poured in to fill the remainder of the ingot mold; the heat of this low carbon steel causes the two materials to weld together. After subsequent heat treatment, the ingots are rolled and machined.

The furnaces used are 224-, 336- and, 560-lb. capacity, built flush into a wooden platform 4 ft. above the general shop floor level. The bodies of these furnaces are supported on trunnions and have their tilting axis about their spouts. Tilting is effected hydraulically.

The water-cooled inductor coils are wound from a special-section high conductivity copper tube and are mounted in supporting stands especially designed for easy removal from the furnace bodies. For cooling these coils, 2000 gal. of water per hr. are required. A self-contained water circulating and cooling system is installed with each furnace.

The generator equipment consists of one 400-h.p., 400-volt, 50-cycle, 3-phase squirrel-cage motor to each end of which is coupled a 150-kw., 2200-cycle, single phase alternator. The output of each alternator is independently controlled and is fed through a main contactor to one of the two power-factor correction condenser banks and via a change-over switch to the furnace coils.

The melting crucibles are built up in place by the Rohn method; they consist of an acid, monolithic-type lining material formed around a mild steel form. In front of the 560-lb. furnace is a circular turn-table which can be moved 1 ft. nearer or away from the furnace. The ingot molds are positioned on this turn-table.

The high carbon steel is melted in either of the two smaller furnaces, then the required amount of metal is poured into a heated hand shank ladle and teemed directly into the inner mold. After the removable plate has been withdrawn, the turn-table is manipulated to bring the mold into position beneath an adjustable tun-dish to take the low carbon steel from the large furnace.

—*Iron & Steel*, Vol. 19, Feb. 1946, pp. 57-60.

FABRICATION and TREATMENT

Machining, forging, forming, heat treating and heating, welding and joining, cleaning and finishing of solid materials. Methods, equipment, auxiliaries and control instruments for processing metals and nonmetals and for product fabrication.

Die Rolling of Steel Products

Condensed from "Iron and Steel Engineer"

In 1920 the Witherow Steel Co. conceived the idea of die rolling, the first jobs being special wire for airplanes and a semi-finished rear axle blank. This axle was rolled from a leader bar to section in one pass. After shearing, a flash was removed and machining was needed only on the spline and wheel ends. In 1925 William H. Donner decided to die roll on his 14-in. mill at Buffalo. Four years later Republic Steel acquired all such mills and became the sole owner of the existing mills and processes.

In 1930 Republic began the manufacture of flashless die roll blanks, which, while not as close to a finished article as the flash blanks, leave sufficient metal for the forger to make the largest part of a projected article and at the same time greatly reduce the metal where less is required. This process was at length licensed to other steel makers.

For a new die roll project the design is first given to the die roll shop. Here two sleeve rolls are placed on one mandrel and the periphery of the rolls is scribed to mark the points where variations in the grooves are to be located. In scribing the two rolls at one time, the same keyway is used and later little adjustment is needed to get the rolls synchronized on the mill. Lathes then cut a lead groove for each pass—a groove corresponding to the smallest dimension desired.

The larger parts of the groove are cut on vertical or horizontal milling machines, or perhaps a fly cutting machine, and require considerable time, skill and patience. Finally, the rolls go to a grinding stand where the grooves are ground and polished to close tolerances.

The length of the blanks desired determines the roll circumference, which varies at Republic from 16 in. to over 32 in. The temperature of the leader bar, speed of the die rolls and surface condition of the rolls may vary the length, surface or area of the die rolled blank.

The amount of reduction, size of the piece being reduced and direction of reduction enter into the making of the desired blank. Reductions may amount to over 75%. Thus, in the rolling of an automotive support arm blank, the equivalent of a 3⅛-in. round is reduced to the equivalent of 1 7/16-in. round.

Brig.-Gen. E. L. Ford, in charge of the Springfield Armory, states that the use of die-rolled blanks had increased the production of Garand rifle and 50 caliber machine gun barrels 40%. At least 7,000,000 die-rolled rifle blanks have been produced. These range from the 24-in. Garand, weighing 5 lb., to the 0.50 cal. aircraft machine gun over 60 in. long and weighing over 51 lb.

Parts made from die-rolled blanks are varied, including automobile crankshafts, front and rear axles, connecting rods, steering arms, steering knuckles, support arms, camshafts, aircraft connecting rods, tank and truck forgings, truck lifting arms, drill bits, pipe wrench jaws and plow beams.

—H. F. Marquardt. *Iron & Steel Engr.*, Vol. 23, Jan. 1946, pp. 68-72.

Infra-Red Drying

Condensed from "Industrial Gas"

Experiments were carried out in Birmingham, England, with gas lighting units, both high and low pressure types, utilizing a medium temperature black panel emitter. Emitting temperatures up to 1650 F were used. These sources gave flux densities very much higher than those required for paint drying on sheet metal although very useful for thick articles.

A 9-ft. tunnel with a bottom conveyor was used for a number of the tests. It had an inner metal lining backed with slag wool. As an alternative to the circular type of oven and to carry out further investigations, a 3-ft. experimental oven with a corrugated surface was constructed. Results indicated the corrugated surface was justified.

For a given thickness of metal, the time to dry the paint film varies considerably with its thickness. It is much simpler to dry sprayed work than that which has been dipped, unless special methods of centrifuging the latter are adopted.

Generally, the synthetic types of paints, having a nominal drying temperature of 250 F, are the most suitable for radiant heating, as they have the shortest drying time. The pigmentation of paint affects the drying times.

With the normal types of paint (formulated to suit rapid drying) used on sheet metal articles, the times vary from 50 sec. to a maximum of 5 min.; heavier sections take longer.

A series of tests were carried out on the drying of small ceramic articles about 3 in. long by ¾-in. diam. Whereas these articles usually were dried in 5 hr. by electrically heated air blown over them, it only took less than half an hr. in the infra-red tunnel.

In order to use infra-red drying successfully, a regular and controllable rate of progression of the articles through the tunnel should be arranged. Also for a given rate, the articles should have approximately similar surface-to-weight ratios, *i.e.*, similar thicknesses. The quantity to be dried should be sufficient so as to be economical.

Articles to be dried at the same time should be coated with the same type and color of paint. Maximum advantage is obtained when paints are used that have rapid drying properties.

—F. L. Atkin. *Industrial Gas*, Vol. 24, Feb. 1946, pp. 13-15, 31-34, 36, 38.

Aluminum Dip Brazing

Condensed from "Aluminum and Magnesium"

The aluminum dip brazing process is the technique of bonding two or more surfaces of aluminum in a molten bath of brazing flux. Aluminum brazing sheet is produced by rolling, and on one or both sides of the sheet is thin surface material which is an aluminum alloy having a lower melting point than the parent metal. Because of this, the application of heat causes the surface to flow at the joints or points of contact, forming a pressure tight enclosure.

The McQuay Co. entered the experimental field in July 1943, when a study of equipment which would heat the Boeing Flying Fortress and effect a weight reduction at the same time was begun. It was the opinion of the Boeing engineers that the glycol then used as the heating medium should be changed to air. It will be noted that the basic fabrication problem in designing air carrying units involved the pressure tight formation of a relatively large number of joints.

During experimentation the desired immersion period was discovered, as well as the effect of temperature and the need for controlled preheating. Tests were also conducted to determine the additional steps required in flux removal from a dip brazed product, and results indicate that thorough cleaning could be accomplished by a series of both still and agitated water and chemical baths.

As in the case of any new development, the first units off the production line varied somewhat in their uniformity. It was found that by adjusting the brazing temperature in accordance with characteristics displayed by a dipped sample piece, uniform output could be secured. Fluorescent light checks for defects or cracks were carefully made, prior to brazing, in order to eliminate processing of defective material.

In the summer of 1944 heat exchangers for portable oxygen generators were produced by dip brazing. The exchangers were designed to withstand pressures in excess of 165 psi. Production was accomplished without any substantial changes in the previously determined techniques.

In shutting down a dip brazing furnace, the flux becomes a solid mass. When the flux is again brought up to dipping temperature, large quantities of impurities will be found and removal is expensive; thus, shut-downs should be avoided whenever possible.

The various products already produced by means of this brazing technique illustrate the possibilities in the use of this method on other light weight enclosures or assemblies such as switch boxes, hydraulic tanks, air duct sections, etc. Experimental work has indicated that low cost high volume output can be attained.

The aluminum dip brazing process will, without question, be securely established in the coming postwar era as a new low cost method.

—C. L. Bensen & R. N. Weber. *Aluminum & Magnesium*, Vol. 2, Dec. 1945, pp. 14-17.

Fabrication of Welded Steel Pressure Vessels

Condensed from "Industry and Welding"

The average welded pressure vessel is fabricated using simple welded butt joints for main seams. These provide for a uniform or smoothly graduated path for stress flow with very few design problems.

It is seldom necessary for a pressure vessel fabricator to go into as complete detail for a welding procedure as may be necessary for a new structural weldment. This is particularly true for thin, mild-steel vessels in which the welds are simple butt joints and where these have some degree of elastic behavior. The welding stresses in thin vessels, however, become a problem insofar as dimensions and tolerances are concerned.

Jigs and fixtures often are satisfactory means for preventing distortion during welding. Welding sequence will also do a lot to control distortion. One interesting method for the accomplishment of this is the use of a double "U" or "V" groove and the simultaneous deposition of root passes.

In heavy plate welds, the additional thicknesses result in a more drastic quench of the molten weld metal, increasing the stress problem, and also results in no yielding to the volumetric shrinkage of the deposited weld metal. In controlling stress failures, consideration must be given to the

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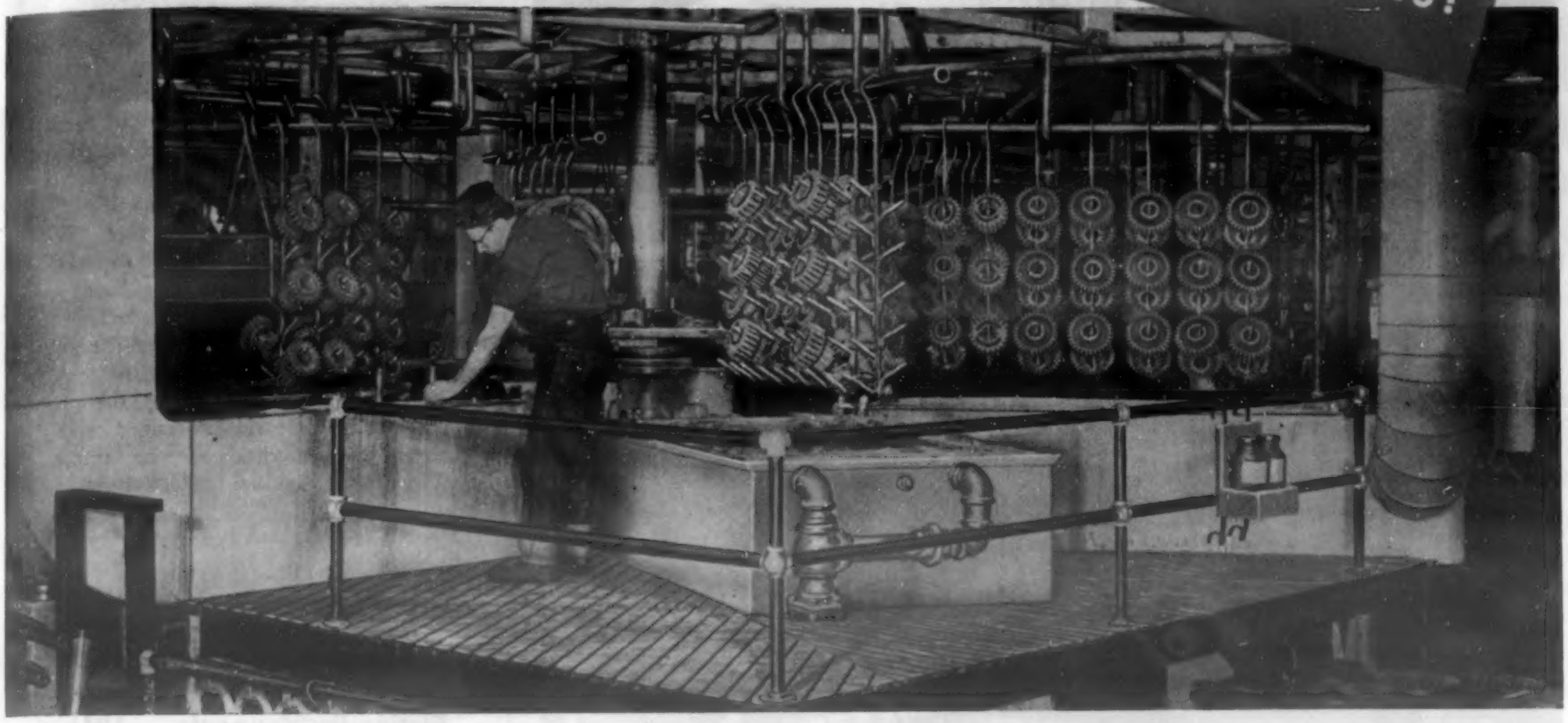

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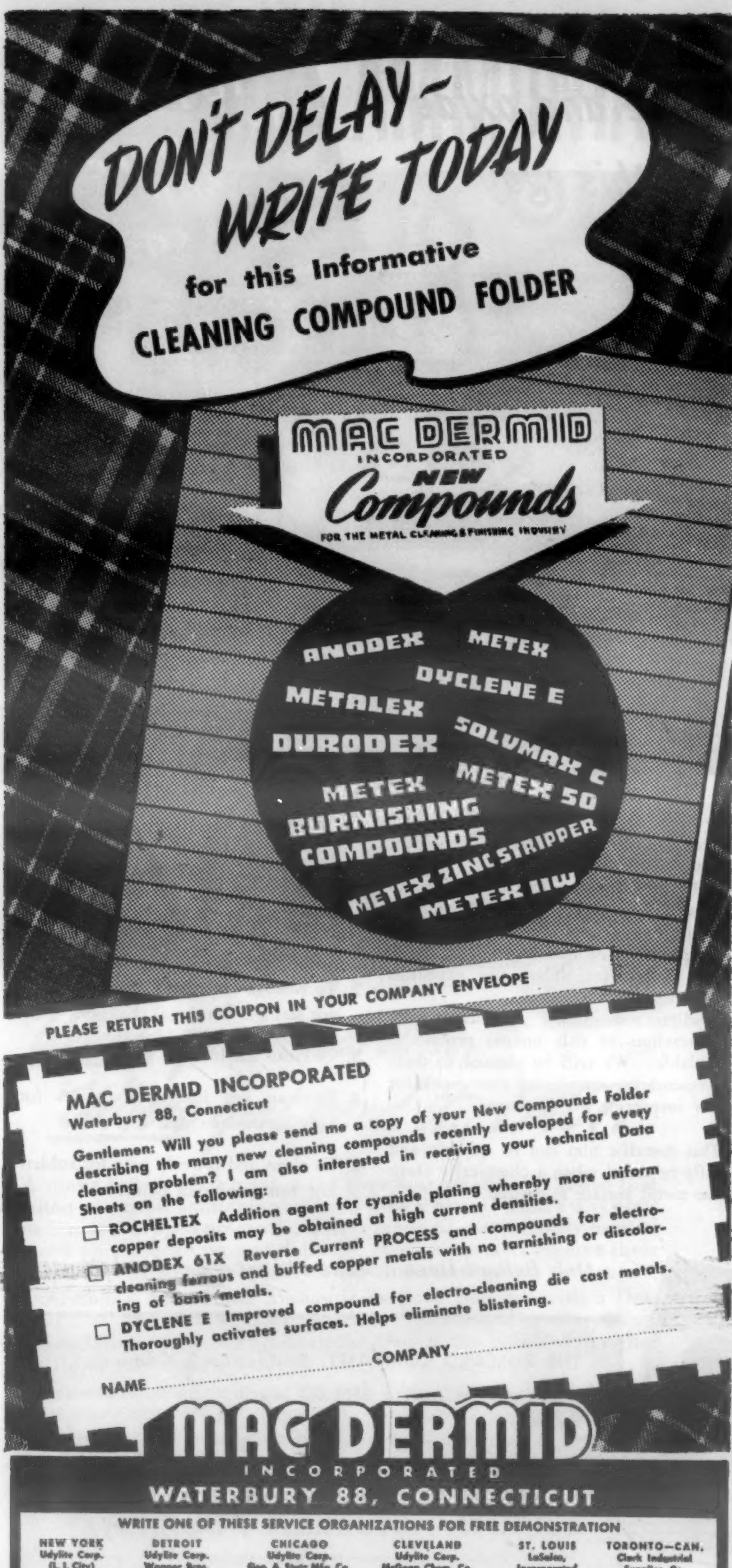


geometry of the weld so as to minimize stress concentration; the proper energy input during the weld as controlled by the size of electrode, number of passes, and rate of deposition; the use of cascade procedures when necessary; sequence of welding to avoid shrinkage stresses; the use of proper preheats, interpass temperatures, and post heats to control properly the quenching effect and the resultant hardening in the heat-affected zone.

It is important to a pressure vessel fabricator that considerations as to plate quality be kept constantly in mind. Experience indicates that most rimmed steels which are over ⅜-in. thick will give serious trouble when welded by high-energy-input method.

Where U-68 construction is to be used and where high energy welding methods are considered, the better grades of steel more than save their extra cost. When vessels are built which are to operate at reasonably high working pressures and temperatures, every possible inspection tool should be employed to determine the soundness with respect to plate quality.

The better grade steel plates, the proper welding technique and procedure, and the right inspection methods are the fabricators only insurance against defective welding.

—O. R. Carpenter. *Industry & Welding*, Vol. 19, Feb. 1946, pp. 44-45, 57-64.

Cleaning and Plating Developments—1945

Condensed from "Metal Finishing"

The theoretical aspects of electrodeposition and surface treatment seem to have been completely neglected during the war years. Last year there were only two theoretical papers; this year none at all. Technical progress, however, is illustrated by the following developments.

Addition of sulphate to chromic acid anodizing baths was found to affect the opacity of the film but not the corrosion resistance. The life of the bath tended to be shortened because of rapid reduction of hexavalent chromium. Other experiments indicated that a high anodizing voltage favors the formation of gamma alumina, and Herrick patented a method for anodizing articles in bulk with the use of a rotating cylindrical container.

New developments were forthcoming in the field of phosphate coatings for iron and steel. Magnesium processing was the subject of important patents, including one for a processing solution of not less than 10% dichromate plus from 6 to 10% nitric acid. Miscellaneous papers and patents were presented and granted for developments relative to chromate films on zinc, passivation of stainless steels, and various oils used as corrosion inhibitors.

A tumbling barrel of novel design was patented, as were many new types of buffing and polishing wheels, discs, pads and rolls. The only paper worthy of note on electrolytic polishing was a complete survey of available literature by Zmeskal. This paper lists all the new developments in that field.

New cleaning compositions were the subject of many papers, one of the most in-

teresting being a cleaner for tin. Degreasing came in for a great deal more attention this year, and patents were granted on organic materials that prevent decomposition of the chlorinated solvents in the presence of aluminum. In the field of abrasive cleaning, a patent was granted for the addition of a liquid which, when applied to the sand blast nozzle, automatically rust-proofs the work being cleaned.

Gilbert's patented development of the molten caustic bath containing sodium hydride was the most interesting in the field of scale removal. A number of acid pickling inhibitors were developed, and new bright dips were patented.

The use of fluoborate baths for the deposition of most of the commonly employed metals was discussed by Narcus, and a timely article covering copper, nickel and chromium plating of zinc-base die castings was prepared by Schoonover. A patent was granted for the deposition of nickel, followed by tin, with the composite coating being heated to diffuse the tin into the outer portion of the nickel.

—Nathaniel Hall & C. B. Hogaboom, Jr. *Metal Finishing*, Vol. 44, Jan. 1946, pp. 2-7, 30.

Rigidizing Light Metals

Condensed from "Modern Metals"

Design rolled or rigidized light metals are a patented product of the Rigid-Tex Corp. of Buffalo, the production of which started late in 1943. Design rolling is a method of form finishing which adds stiffness, impact and buckling strength to give high strength-weight ratios in metals such as aluminum, magnesium and stainless steel. Various patterns have been designed to give a variety of textured surfaces for utility, decorative and engineering purposes. The increase in over-all thickness in some cases is 100 to 800%.

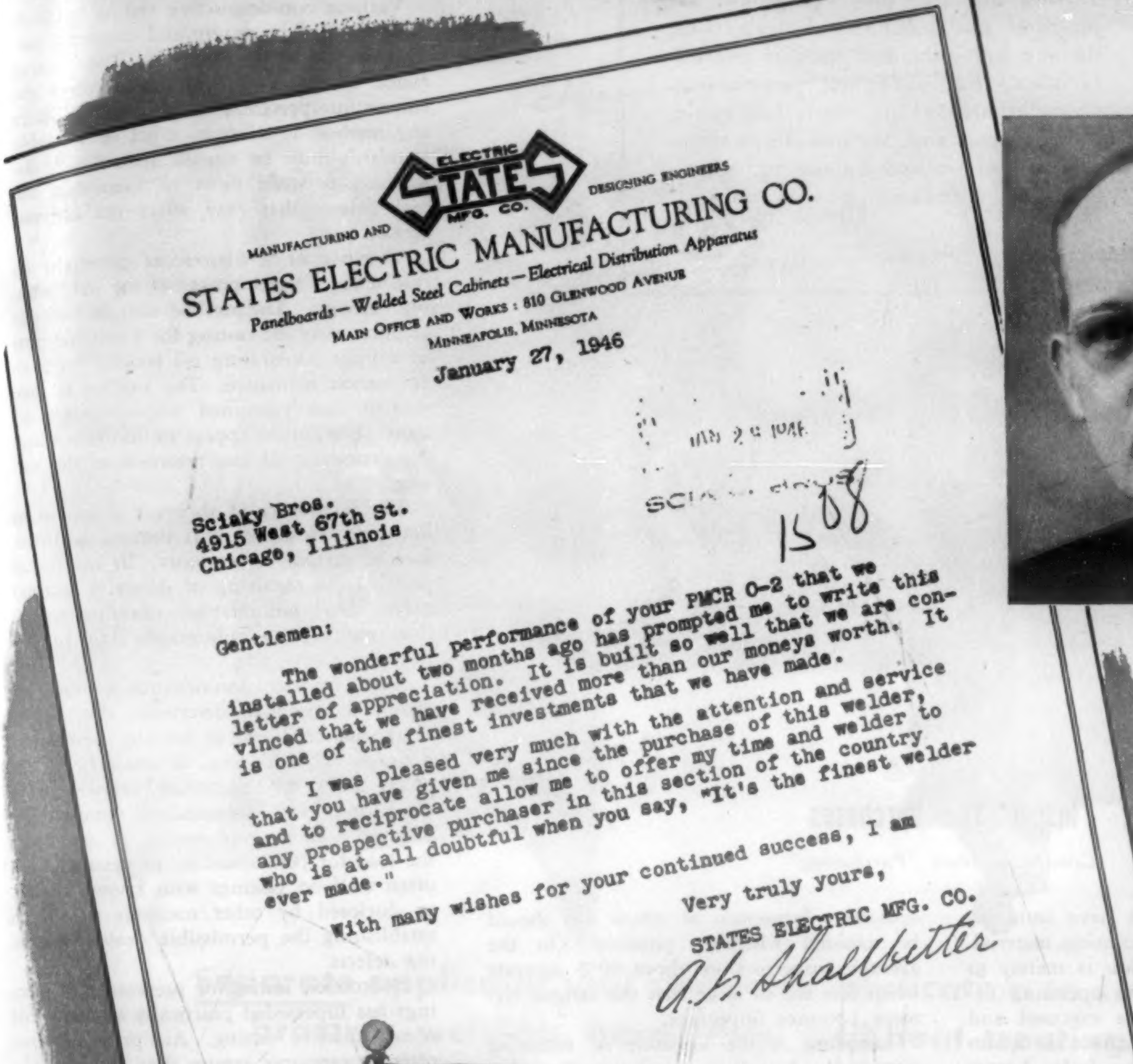
This material has many advantages over ordinary corrugated sheet. There is no appreciable increase in unit weight as compared with a minimum of 50% for corrugated material. With design rolled material, the stiffness is increased at various angles to the direction of rolling while the corrugated material is stiffened in only one direction. The added cost of design rolling is more than offset in many cases by the saving in metal consumed.

In general, design rolled metals may be fabricated by the same methods used for plain flat rolled metals. Two recent developments—welded tubing and perforated sheets—are of particular interest. In the case of the tubing, it can be sunk without destroying the patterned surface.

Design rolled ferrous and nonferrous material is available in strip and sheet up to 36 in. wide. Fifteen standard patterns are available, and others can be engineered for exclusive use if there is sufficient volume involved to warrant the tool cost. This material is already finding acceptance in a variety of light metal consuming industries, such as aircraft, architecture, automobile, railroad and others.

—R. S. Smith. *Modern Metals*, Vol. 2, Feb. 1946, pp. 8-11.

Them's Strong Words, Mr. S.!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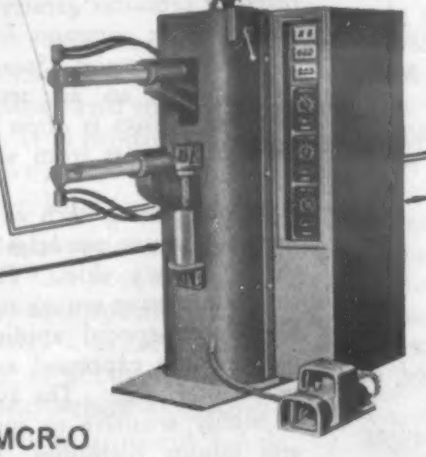

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Write for descriptive bulletin No. 112-D

YES SIR! When the busy owner of a plant making electrical distribution equipment takes time out to sit down and write the above letter, he must have something to shout about.

It's the result of a long-standing conviction on the part of Sciaky Bros. that resistance welding is strictly a *production process*. Machines must therefore be designed to both, (1) produce sound welds and (2) stand up under continuous production conditions. To this end, Sciaky welders are engineered for *long life* and to be as *maintenance-free* as possible.

Furthermore, when you have trouble (and who doesn't, now and then), our service engineers are always on call to help out. We'd like to have the opportunity of proving "It's the Finest Welder ever Made" to you, too.

SCIAKY BROS.

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TESTING and INSPECTION

Testing methods and equipment for physical and mechanical properties, surface behavior and special characteristics. Radiographic, spectrographic, identification, metallographic, dimensional and surface inspection. Stress analysis and balancing. Specifications, standards, quality control.

Inspect Your Purchases

Condensed from "Purchasing"

Many purchasing agents have little interest in the quality of incoming material. They consider that their job is merely to see that the requests of the operating departments for materials are executed and that invoices are checked against the quantity arriving at the receiving dock. Agents who lived under that concept in pre-war days are due for a rude awakening.

There should be two specifications in a purchase contract: the material should be specified and evidence required in the receiving department that the material meets the specification. Much disagreement between vendors and purchasing agents during the war was due to the absence from the contract of this second part. Bundles of correspondence in purchasing files deal with disagreements on inspection results, inspection methods, types of inspection equipment, standards of smoothness, appearance, conformance to hardness or tensile requirements, etc.

Often the main question is: When is a lot defective? Some of the principles of receiving inspection are fairly well defined by experience. There are nine typical rules. Avoid destructive testing where possible. This wastes materials and consumes time. Fixed gages are preferable to variable gages. "Go-no-go" gages are faster than other kinds and require less skill. All gages must be laboratory checked frequently to insure accuracy.

Standards should be established for all visual inspection, and approved standards should be kept immediately before the operator. Inspection of whole lots should be avoided wherever possible. On the average, inspectors are about 90% accurate when lots are so large that the fatigue element becomes important.

Sampling is the keystone of receiving inspection. A well designed sampling plan will maintain quality as well as 100% inspection and at much lower cost. Modern sampling abandons fixed sample sizes as well as samples, which are a fixed percentage of the lot. The principle is to maintain fixed quality protection.

Sample sizes are kept at the minimum consistent with the desired quality protection, which reduces inspection cost and inspector fatigue. Samples must be representative of the lots from which they are drawn, and inspectors must be trained in acceptable methods of taking samples.

There are three well-defined sampling plans available: Army Ordnance, Dodge-Romig, and the Sequential. Someone in the Purchasing Department should be fairly familiar with the details of whichever is used. Proper classifications show which part a particular vendor supplies within limits and which he does not.

Some buyers hold that vendors are permanently responsible for the quality of goods sold; at the other extreme are clauses which limit responsibility to 30 days. Parts such as castings or forgings which may contain concealed defects that will effect machining adversely require a different concept of vendor responsibility.

—M. A. Brumbaugh. *Purchasing*, Vol. 20, Feb. 1946, pp. 86-88.

Non-Destructive Testing for Castings

Condensed from "American Foundryman"

Various non-destructive testing methods other than radiography and magnetic particle inspection are discussed. The limiting factor controlling their use involves the correct interpretation of the results. Before any method is adopted, a set of workable standards must be agreed upon which distinguish between flaws or blemishes and real defects that may affect the ultimate service.

The use of a fluorescent penetrant on castings is a development of the old "whiting" method. The method consists basically of immersing the casting for a suitable time in a light penetrating oil treated for high fluorescent brilliance. The casting is then washed and examined under ultra-violet light. The defects appear to fluoresce where the penetrant oil has returned to the surface.

The popularity of this test is due to its low cost. However, it is limited to disclosure of surface defects only. Its use makes possible the repairing of defective castings before final radiographic examination. It does not replace radiography but supplements it.

Static loading non-destructive tests are commonly used to determine the quality of the material and to develop satisfactory designs. The loading is usually 1.5 or more times the maximum service loads, so castings with substandard strength are detected. Static proof testing to determine the load for permanent set or destruction is often used on castings with known defects as disclosed by other methods to aid in establishing the permissible extent of casting defects.

Hydrostatic testing of pressure type castings has superseded practically all forms of non-destructive testing. Air pressure tests, often at pressures greater than the working pressure, are common with castings to be immersed in water. Steam, cold or hot oil pressure, or an air test of unmachined pressure fittings is often used to detect defects which pass from wall to wall of the casting.

Acoustic tests, such as striking a casting with a hammer, are largely dependent upon the operator's skill. The application of supersonic wave testing to castings has been limited to special applications and could be generally expressed as being in the experimental stages. The available equipment is highly sensitive to surface irregularities and minute blemishes. When these difficulties are overcome, this method may gain in use and popularity for non-destructive testing.

Electrical methods of flaw detection in castings have been tried with limited application and degree of success for some types of castings. However, there are two methods used for segregating materials of varying analysis and states of heat treatment although they are not suitable for disclosing defects or flaws. One is based upon the change in electromotive force induced by the test piece as compared with that of a known standard.

The cyclograph uses the principle of varying metallurgical properties that cause

variation in the core loss of a tuned pick-up coil which surrounds the piece under test. This instrument is limited to uniform casting sections which can be inserted into a suitable coil.

—J. W. Juppenlatz. *Am. Foundryman*, Vol. 9, Jan. 1946, pp. 38-41.

Etching for the Microscope

Condensed from "Metal Treatment"

The etching of metals with acids and other corrosion-producing solutions for the examination of specimens under the microscope has been practiced for the last 200 years. The surface to be etched must be carefully polished, reasonably scratch-free and show no signs of surface drag. Newer methods of mounting in Bakelite or other plastics are preferable to older methods in solder or Wood's metal, since the latter is detrimental to the microscopic examination of the specimen edges.

After polishing, the specimen must be cleaned carefully, rinsed in alcohol and dried, preferably in a hot air blast. Etching gives a relief, contrast, or sometimes color effect to the various constituents in the sample. The simplest etching method is to immerse the specimen in a dish filled with the etching solution, with the polished face up. A slight motion of the liquid is helpful, the specimen being handled with tongs.

Another is the drop-by-drop method, the specimen being held in the horizontal position and as much liquid dropped on the surface as can be held there by surface tension. Another way is to place the etching solution on the polishing cloth at the final stages of polishing.

The author favors etching by swabbing, the surface being rubbed with a wad of cotton-wool soaked with the solution; this removes the surface film and permits a more uniform attack. The electrolytic method is used for highly alloyed metals, making the specimen the anode, with platinum the cathode and an electrolyte composed of the etching solution.

The time of the etching is important and learned by experience. If the etching is too light it can be treated again; if too heavy, the specimen must be repolished. Cast iron must be etched carefully lest soft graphite be torn out, leaving the surface pitted. Cast iron is apt to stain and, if this is to be prevented, it is wise to immerse the specimen in a 50% solution of ammonium hydroxide for a few seconds before etching.

For cast iron several reagents may be used. A 4% solution of picric acid in alcohol is the best general reagent, bringing out the ferrite, pearlite and steadite. A 2% solution of nitric acid in alcohol (nital) is sometimes used instead of the picric acid, though it may roughen the surface. It is good for developing ferrite grain boundaries, meanwhile overetching any pearlite.

Ten percent ammonium persulphate is ideal for differentiating between ferrite and steadite. The following solution is used for distinguishing between ferrite and cementite: Add 2 g. of picric acid to 100 cc. of water in which 25 g. of caustic soda are dissolved.

For etching steel the most universal solution is 1 to 10% of nitric acid in alcohol.

Free carbides in carbon and low-alloy steel are revealed by etching in alkaline sodium picrate. For distinguishing chromium and tungsten carbides the following is used: 10 g. of potassium ferricyanide and 10 g. of potassium hydroxide in 10 cc. of water.

The etching of a nitride case is best carried out with a 5% solution of picric acid in alcohol. The following is the commonest solution used for stainless steels: ferric chloride, 10 g.; hydrochloric acid, 30 cc.; water, 120 cc.

—C. A. E. Wilkins. *Metal Treatment*, Vol. 12, Winter 1945-1946, pp. 233-241.

Railroad Laboratory

Condensed from "Railway Age"

The Rock Island Lines has recently opened in Chicago a specially designed testing and research laboratory building, fully equipped for testing the 70,000 items used in railway operation and maintenance. It is a one-story reinforced-concrete structure, with a floor area of 16,275 sq. ft., having exterior walls of red shale brick, glass blocks, and continuous lines of horizontally-hinged windows.

Fluorescent lighting is used throughout the building, and clear glass is used extensively in the interior partitions. Painting scheme of the machine-shop and physical-testing laboratory is in accord with the so-called color dynamics system. This section is devoted largely to testing all engineering materials, and is served by an overhead two-ton traveling crane. Specimens of all rail failures are sent to this laboratory.

A large constant temperature room will be equipped with humidity control and heating and refrigerating facilities, whereby temperatures ranging from –25 to 125 F may be maintained over considerable periods. Later it is planned to apply lead lining to this room for X-ray investigations. The rubber-testing laboratory performs the necessary tests on air, signal, and steam hose; gaskets; packing; and various upholstery and textile materials.

There is a laboratory which is fully equipped for the accelerated testing of protective coating and corrosion-resisting materials. In addition, an outdoor test rack is located on the roof of the building. All test panels are prepared in an explosion-proof and fire-proof room, which is used also for routine physical testing of protective coatings. Chemical analysis of these materials is carried out in a separate room.

One of the most important laboratories is that devoted to petroleum products. It contains modern apparatus for maintaining careful control of fuel oils, lubricants, etc. used in the road's fleet of Diesel locomotives. A series of field tests by maintenance men at the end of locomotive runs have been developed.

Among other laboratories and rooms are those for analysis of water; testing and analysis of cement, coal, ballast, and concrete aggregates; metallographic examination; macro-etching and sand-blasting; spectro-analysis; testing of electrical apparatus and equipment; electronics tests and research; stationary dynamometer car; and miscellaneous analysis and testing.

—*Railway Age*, Vol. 120, Feb. 16, 1946, pp. 359-365.

BOOK REVIEWS

Directory of Alloys

ENGINEERING ALLOYS. *By Norman E. Woldman & Roger J. Metzler. Published by American Society for Metals, Cleveland 13, Ohio, 1945. Cloth, 6 x 9 in., 834 pages. Price $10.00.*

This compilation of trade names of alloys and their manufacturers, together with their important properties, has appeared as a second edition of the well known work originally authored by Woldman and Dornblatt There has been no radical change in the new edition. The information has been brought up-to-date, obsolete data have been deleted, and the section in the first edition devoted to references (Sect. VI) has been omitted as unnecessary.

As was the case with the previous edition, the engineering alloys are listed alphabetically in Section One. In Section Two are found the alloy trade names, compositions, properties, uses and manufacturers' key numbers listed according to the serial numbers established in Section One. The alloys, represented by their serial numbers, are classified according to their special characteristics and uses in Section Three. Section Four comprises a directory of manufacturers and their products listed alphabetically. Section Five is a listing of alloy manufacturers by the key numbers referred to in Section Two. A Useful Data Appendix is Section Six, while the last section is devoted to advertisers.

Unfortunately, there have been some mechanical errors in the make-up of this volume. To follow the alloy serial numbers in sequence, one has to turn from page 243 to 245, then back to page 244 and then to 246, which could be highly confusing to one seeking information in a hurry. On the whole, however, the volume maintains the high standard of utility of the first edition and is, of course, in a class by itself as a directory of alloy tradenames.

—R. S. BURPO, JR.

Electroplaters' Chemistry

CHEMISTRY FOR ELECTROPLATERS. *By C. B. F. Young. Published by Chemical Publishing Co., Inc., Brooklyn, N. Y., 1945. Cloth, 5¾ x 9¾ in., 205 pages. Price $4.00.*

This book greatly condenses general inorganic chemistry from a first-year college level in a very unusual but interesting manner. The elementary chemistry of solutions is simply and understandably stated.

Typical chemical reactions of the common elements are used extensively; the gas laws, valence, ionization, concentration of solutions, types of reactions, etc., are tersely explained. Yet, the subject matter is so highly condensed that much study and thought would have to be applied by anyone reading the book for his first introduction to chemistry.

One might seriously question the value of a two-page discussion on atomic structure and a brief discussion on the shortcomings of the periodic classification of the elements. The important matters of pH, buffer action, mass-action effects of solutes, e.m.f. relationship of elements, might well have been included in the discussion to better advantage for electroplaters, than discussions on the chemistry of silicon, arsenic, or how wrought iron is made, to name several topics.

The smelting of iron and the manufacture of steel and alloys are interesting, yet are not particularly pertinent to chemistry for electroplaters. A discussion of the e.m.f. relationship of the elements would undoubtedly be as, if not more, beneficial to a plater than reference to the law of octaves.

It would be helpful to electroplaters to find more specific but elementary reference to volume and weight relationships for analytical control of solutions.

The reader must conclude that this book is not so specifically directed to the electroplater as it could be.

—C. L. FAUST

Principles of Electron Optics

ELECTRON OPTICS AND THE ELECTRON MICROSCOPE. *By V. K. Zworykin, G. A. Morton, E. G. Ramberg, J. Hillier & A. W. Vance. Published by John Wiley & Sons, Inc., New York, 1945. Cloth, 5⅞ x 8⅜ in., 766 pages. Price $10.00.*

Dr. V. K. Zworykin and a group of his associates at RCA Laboratories have done a book outlining the optics of the electron microscope. The book contains comprehensive non-mathematical descriptions of the electron gun, of magnetic and electrostatic lenses and their abberations, and of the fundamentals of the electron trajectory and its control upon which they are based. For anyone making a serious study of the theory underlying the electron microscope, here is a valuable reference work.

(Continued on page 1396)

For the practical man, to whom the electron microscope is simply one of many available tools, each to be used when needed, a warning is necessary. The book is not a manual of electron microscope technique. About one hundred of the 750 pages are devoted to manipulation of the instrument itself. The remainder are devoted to discussing the theory which makes the instrument possible. The book is precisely what its title indicates—an outline of the principles of electron optics.

—KENNETH ROSE

Other New Books

SYMPOSIUM ON MAGNETIC PARTICLE TESTING. *Published by American Society for Testing Materials, Philadelphia, Pa., 1945. Heavy paper, 6 x 9 in., 122 pages. Price $1.25.* The combination of papers presented comprises a miniature textbook upon the subject. Included are outlines of the equipment used, the theory underlying its use, and the application of the method to railroad equipment testing, aircraft parts testing, inspection of castings, and inspection of forgings. A.S.T.M. tentative methods for magnetic particle testing and inspection of commercial steel castings and for heavy steel forgings are included.

A BIBLIOGRAPHY ON CUTTING OF METALS. *Prepared by O. W. Boston. Published by The American Society of Mechanical Engineers, New York, 1945. Fabrikoid, 5¾ x 8¾ in., 547 pages. Price $6.50.* This bibliography combines Parts 1 and 2 published in 1931 and 1935, respectively, with 3500 additional items. The 4124 annotated references are arranged alphabetically by authors and chronologically by years, and provide a comprehensive list of the most important articles on metal cutting, including shaping, grinding, analysis and treatment of the various cutting tools, turning, milling, drilling, planing, shaping, broaching, reaming, etc. They embrace the years 1864 to 1943, inclusive.

ACID OPEN HEARTH SLAG FLUIDITY AND ITS SIGNIFICANCE. *By G. R. Fitterer, J. W. Linhart, B. B. Rosenbaum, J. B. Kopec, S. Poch & W. G. Wilson. Published by Acid Open Hearth Research Assoc., Inc., Pittsburgh, 1945. Heavy paper, 6 x 9 in., 60 pages. Price $1.00.* This is the first bulletin of the Acid Open Hearth Research Association, Inc., established in September 1942, by a group of companies making this grade of steel. This bulletin describes some of the results of the research staff's investigations on the fluidity of slags in acid open hearth operations. The information is believed to be of considerable value in the orderly working and control of an acid open hearth heat of steel. Not all the results on the fluidity study were available for publication at the time the bulletin was prepared, but further information may be expected. The research activities are carried on by a staff under the supervision of the Association's Director of Research at the University of Pittsburgh.

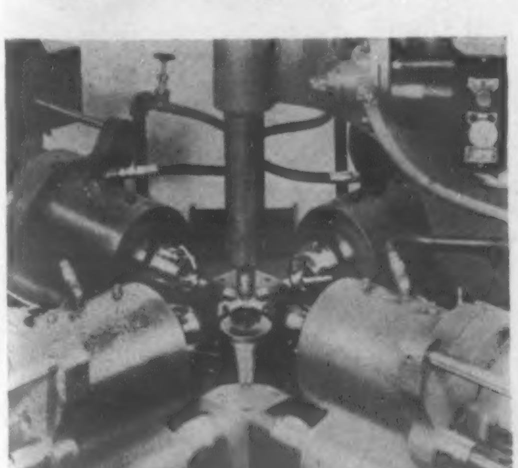
BEHAVIOR OF FERRITIC STEELS AT LOW TEMPERATURES, PARTS I AND II. *By H. W. Gillett & F. T. McGuire. Published by American Society for Testing Materials, Philadelphia, 1946. Heavy paper, 8½ x 11 in., Pt. I—56 pages, Pt. II—156 pages. Price $4.00 ($3.00 to ASTM members).* The two parts of this report cover extensive data based on experimental work which the War Metallurgy Committee carried on at the University of Kentucky. Data from other sources are also included. The project as conceived by the War Metallurgy Committee was aimed to secure a comprehensive set of experimental data on the low-temperature behavior of commercial, national emergency, S.A.E. and similar steels, and to clarify the relation of composition, heat treatment, grain size, etc., to low-temperature behavior. Part I, 56 pages, contains an extensive discussion of the project, the materials and the resulting data, with tabular material and references. Part II, 156 pages and 250 diagrams, photomicrographs, etc., contains the developed data with many figures and charts.

Recent Machine Tool Developments

Much intensive experimental and development work is constantly being carried on by the machine tool industry to provide the metal working field with equipment to handle the ever-changing machining problems. Here are brief descriptions of a number of recent machine tool developments.

Milling Machines and Lathes

A line of knee-type milling machines designed for maximum efficiency when milling steel with carbide cutters has been developed by *Kearney & Trecker Corp.*, Milwaukee, Wis. The design of this type miller includes a solid-back column and a spindle drive motor cross mounted in the base. Power is transmitted to the spindle through multiple V-belts and the spindle speed selection box. Sixteen speeds from 50 to 1250 r.p.m. in approximate geometrical progression are possible. Feed rates from ⅜-in. to 90-in. per min. in approximate geometrical progression are also provided.



This hollow milling machine is made up of four separate units which may be operated together or singly.

A hollow milling machine for heavy duty work has been developed by *LeMaire Tool & Manufacturing Co.*, Dearborn, Mich. The machine is composed of four separate working units arranged at right angles to each other, about a central base, which carries a fixture for mounting the work. Each of the machines can be operated independent of the others.

The spindles are mounted in housings which slide on large guide bars. The coolant is forced inside the spindle under pressure to provide efficient chip removal. The machine was designed to hollow mill and face shoulders on universal joint spiders with journals ranging from ½-in. to 1⅛-in.

A milling cutter redesigned by the *Lovejoy Tool Co., Inc.*, Springfield, Vt., is said to provide for sensitive control of blade settings. To accomplish this, each blade is set at a slight angle to the cutter body. When blade adjustment is required, a locking device is loosened by unseating a taper pin. A recessed-head screw, at the bottom of each blade, is then turned to move the blade up or retract it the exact amount required.

R. K. Leblond Machine Tool Co., Cincinnati, has announced the introduction of four new model automatic crankshaft lathes. Although there is some overlapping of functions, these four machines complement each other and all together perform a variety of turning operations such as rough and finish turning, fillering, checking, and shaving.

A small, high-speed lathe for use on bench or table has been developed by *Precise Products Co.*, Racine, Wis. It is most applicable for grinding and polishing small products and parts such as screw machine parts, precision castings, and carbide tools and blanks. It can be used for steel, nonferrous metals, plastics, glass and wood.

Phantom view of milling cutter showing how each blade is set at a slight angle to the cutter body.

A single spindle automatic chucking lathe for machining operations on castings, forgings and tubing parts up to 12 in. in diam. has been announced by the *National Acme Co.*, Cleveland 8. This new machine specializes in straight, internal or taper boring, form turning or form boring, external turning, forming, facing and chamfering.

Grinding Equipment

The *Cincinnati Milling Machine Co.*, Cincinnati, has recently announced the development of a grinder for sharpening cutter shapes involving convex or concave radii, and having straight, tapered or helical teeth. The generation of accurate radii is accomplished by the turntable base upon which the workhead unit is mounted. The workhead may be swiveled through 235 deg.; adjustable stops are provided to limit its arc of travel. An adjustable trans-

verse slide provides for the grinding of radii which have their centers offset from the centerline of the workpiece.

For grinding flat form contours the crush grinding principle is receiving widespread interest. The *Thompson Grinder Co.*, Springfield, Ohio, has developed a crush forming machine which utilizes two master rolls. One roll does the initial crushing of the grinding wheel to the form desired; the second roll is used for touching up the wheel and correcting form loss. Both rolls are mounted on the working table in such a way that the grinding wheel can be initially crushed, the work can be formed, and the grinding wheel retouched for form loss without disturbing the set-up.

Accessories

A drill chip breaker which breaks the chip at each revolution of the drill has been introduced by the *Ex-Cell-O Corp.* of Detroit. In operation, the short chips accumulate around the mouth of the hole, thus eliminating the troublesome long, whirling spirals. The main benefits are said to be increased operating speed and prolonged drill life.

A new type of machine vise for use with millers having a flat table surface with "T" slots is being manufactured by the *Posterfield Mfg. Co.*, Los Angeles 21, Calif. This vise makes use of the flat table surface of the miller and thus allows the full vertical capacity for work from table surface to cutting tool, as well as the full length of flat table surface.

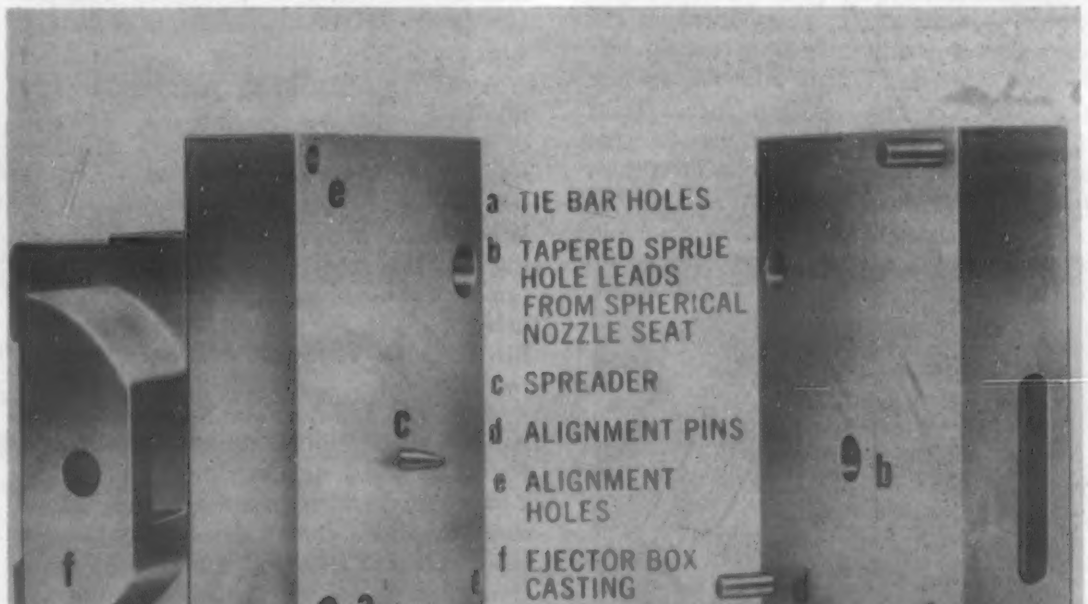
How the chips look after being broken up by the drill chip breaker.

High-Speed Die Casting Machine for Small Runs

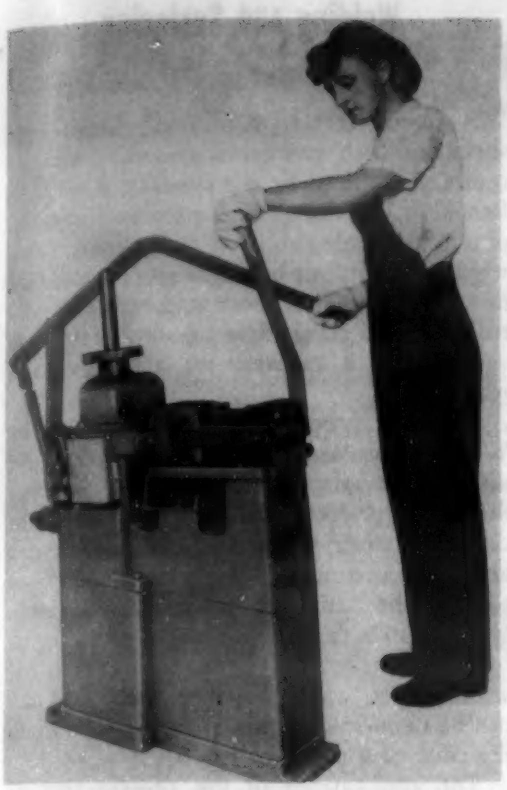
One of the factors in the selection of the method for producing a small part is the quantity of parts to be made. The selection of pressure die casting, as a method for making small metal parts, has been largely confined to those applications where large runs of over 1000 parts are required. The cost of the dies generally has made the use of die casting for small runs or for experimental purposes prohibitive.

A die casting machine designed primarily to make the die casting of small quantities of parts economical has been introduced during the past few months by the *DCMT Sales Corp.*, New York 13. The machine was developed and first used in England, where during the war it was applied to the manufacture of a number of war products.

This design of die casting equipment has been used successfully for runs as low as



Prefabricated blank die sets cut cost of die making for small runs.



The small hand-operated die casting machine capable of 500 to 700 shots per hr.

300 parts, and production rates of 500 to 700 shots per hr. have been achieved.

Prefabricated Dies

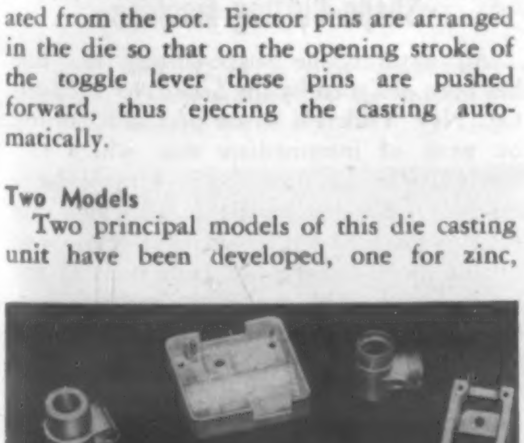
One of the chief features of this new equipment is the use of prefabricated blank die sets. The die sets are made available to the user with the alignment pins and holes, the sprue hole, the spreader, etc. already built in. Thus, the die making operation consists only of machining the die cavity and grinding the gate. The user in many cases can make his own dies.

Because of the production rates possible, the use of single impression dies instead of the multi-impression type becomes practical. This further simplifies the die making operation and cuts the die cost.

The required die cavities are cut either directly into the die plates or in steel pads that can be fitted to the die plates. Automatic or hand-operated side cores can be arranged where required. The fixed die-half is water-cooled to counteract the heat radiated from the pot. Ejector pins are arranged in the die so that on the opening stroke of the toggle lever these pins are pushed forward, thus ejecting the casting automatically.

Two Models

Two principal models of this die casting unit have been developed, one for zinc, tin, or lead base alloys; the other for aluminum. The machine designed for zinc, tin and lead base alloys can produce parts up to 5 oz. in weight and approximately 5 in. by 7 in. in size.



A few of the parts which can be produced on this type die casting machine.

The machine is made up of two units—the pot unit and the die unit. The casting metal is melted in the gas-fired pot. The plunger, hand operated, injects the molten metal through the goose neck into the die. The moving half of the die is opened by hand to remove the casting. This type of machine is also available with an air operated plunger.

The aluminum die casting machine will produce parts up to 2½ oz. in weight and approximately 5 in. by 6 in. in size. It is composed principally of a die unit and injection cylinder. The molten aluminum is poured from a ladle into the injection cylinder through a pouring slot.

An air-operated plunger forces the metal into the die. The fixed die-half is secured to the water cooled injection cylinder cradle. Additional water cooling is required in the die-blocks after the form has been cut.

Recent Developments in Control Valves

In many metal working plants control valves form an important and integral part of the processing and fabricating equipment. Below are listed a number of such control devices recently announced by manufacturers of control equipment:

A self-sealing, air operating ball type valve, known as "Type BA." Fitted with a hand opening lever and a rotatable pivot. Ball valve closes tight with inlet pressure. *Leslie Co.,* Lyndhurst, N. J.

A solenoid-controlled 3-way valve for compressed air provides straight line air flow control. The user can select the setup desired by reversing the supply and outlet manifolds on the center body. *Numatics,* Milford, Mich.

A differential oil flow control valve for providing constant liquid fuel flow to regenerative furnaces. May be applied to other liquid fuel control problems. The valve prevents liquid flow changes due to pressure variations. *Bloom Engineering Co.,* Pittsburgh.

Three air and hydraulic control valves. One is for tubing and light piping applications, designed for 4-way operation. Suitable for air, oil or water in pressures up to 250 psi. Another is a foot-operated valve for use in air and oil hydraulic cylinder applications. Operates on 250 psi. air pressure or 1,000 psi. oil pressure. A third is a two-direction speed control valve for adjustable control of cylinder piston speed in both directions. Working pressures are 250 psi. for air cylinders, 1,000 psi. for hydraulic. *Hanna Engineering Works,* Chicago 22.

A hydraulic remote control for throttle, mixture, governor, and position indicator controls. The unit is very small, completely enclosed, and easily installed. *Sperry Products, Inc.,* Hoboken, N. J.

A magnetic relay for use in electronic and industrial fields where relays are required for operation on currents of thermocouple and photocell magnitudes. *Instrument Div. of Thomas A. Edison, Inc.,* West Orange, N. J.

Welding and Surfacing with Powdered Materials

A new method of welding, brazing or surfacing with powdered materials was recently announced by the *Powder Weld Co.*, Brooklyn, N. Y. The equipment consists of a torch, made similar to an ordinary flame welding torch, but having a special patented nozzle and 16 independent controls, a control box with air and gas pressure regulating valves, and a canister for the powdered materials.

In this process, known as "Powder Weld", compositions of powdered or finely divided metals, together with suitable fluxes, are projected through the flame cone onto the work surfaces. Fuel gas, oxygen and a processing gas are used together to provide the flame and temperature control.

The torch can be used as a welding or brazing torch with conventional rod or wire. When used in this manner, the flux can be deposited in powdered form through the cone of the flame.

The applications of the process include hard facing, brazing and welding with powdered metals and alloys, controlled atmosphere welding and metal spraying of all kinds. The method can also be used to apply various chemical compositions of the plastics group to surfaces.

● For making lap joints in copper strap, attaching terminals to cable, brazing coil ends and general copper smithing work, a new portable 5 Kva brazer weighing only 30 lb. is announced by the *Westinghouse Electric Corp.*, Pittsburgh. The brazer consists of a transformer, voltage selectors, controls, and carbon-tipped tongs. Alternating current from an adjustable voltage transformer passes through the tongs and parts to be brazed, raising the temperature to a point at which the brazing alloy melts. The brazing alloy may be applied in the form of a rod or in ribbon form.

Shape-Cutting Machine

An oxyacetylene shape-cutting machine has been designed by the *Linde Air Products Co.*, New York 17, to do precision cutting on work of intermediate size, which formerly could be done only with a large machine. An attachment is also available for this machine which makes it possible to mount the blowpipes on both sides of the tracing table. This makes the machine particularly adaptable to high production setups by permitting the cutting of identical shapes simultaneously from plates on both sides of the tracing table.

The attachment can also be used to great advantage in eliminating "down time", since plates can be put into position on one side of the machine while cutting is being done on the other.

The machine has a 36-in. transverse working range. The longitudinal working range with the standard table is 100 in., and this range can be extended indefinitely by adding frame and table top sections.

Metal Cutting Saws for Light Gage Applications

Two metal cutting saws, one a high-speed band saw and the other a hand operated saw, were announced recently by two companies. The *Doall Co.* of Minneapolis is the manufacturer of the band saw, designed primarily for light gage steel and foundry work. The saw is capable of slicing through ⅛-in. stainless at 48.6 lineal in. per min., and through 13 gage sheet steel at 150 in. per min.

This air operated hand saw is handy for sawing light gage metals.

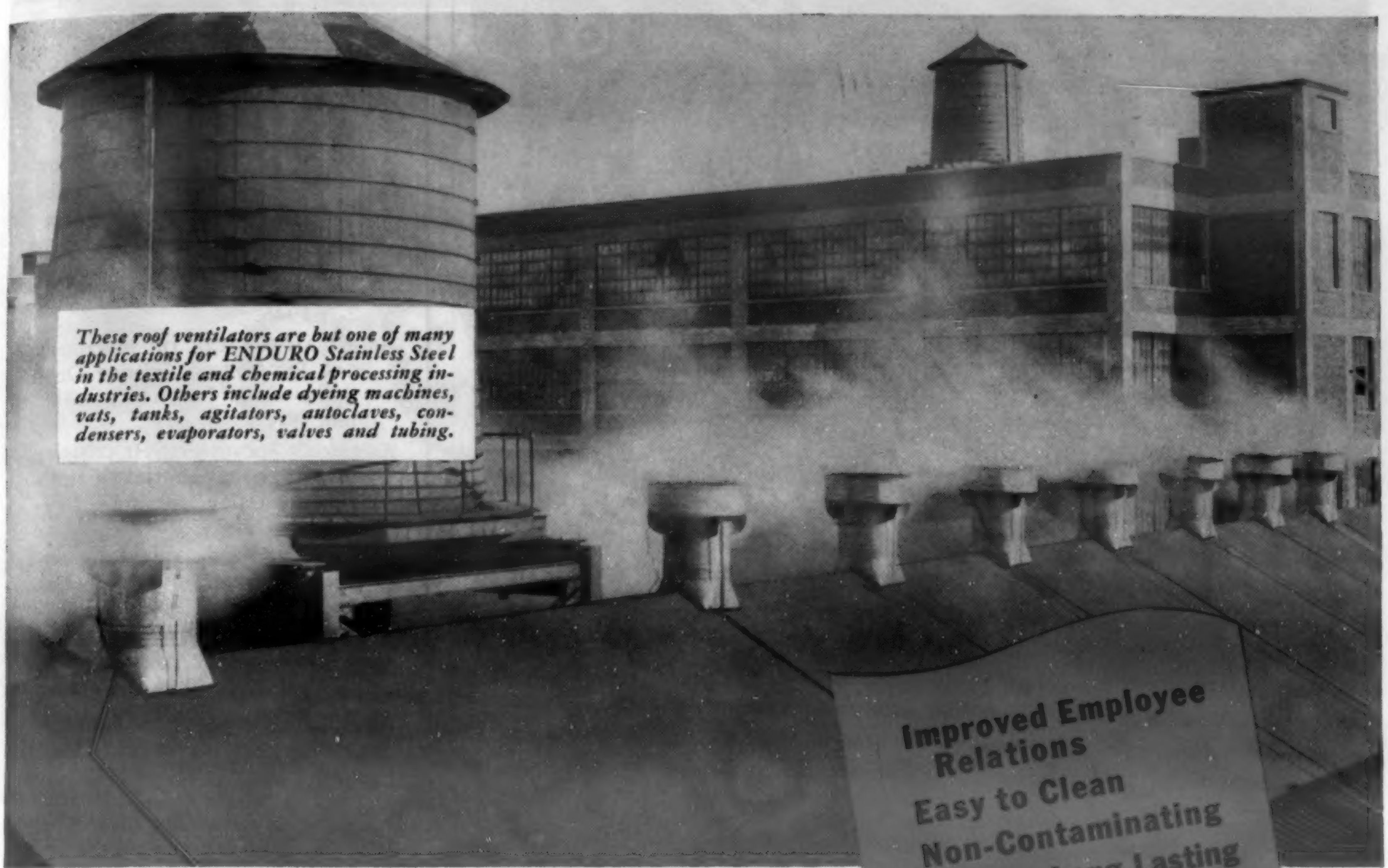
The hand saw, air operated and designed to use standard sizes of hack saw blades and files, is distributed by the *Air-Speed Tool Co.*, Los Angeles 44. This saw is portable and especially suitable for working in awkward or cramped quarters.

Degreasing Equipment for Small Parts

A conveyorized machine for cleaning small basketed parts has been announced by the *Detrex Corp.*, Detroit. The equipment is a two-dip immersion vapor degreaser which permits the choice of any one of several cleaning cycles. The first choice is an immersion-vapor cycle. Work being cleaned is dipped in hot solvent in the first chamber and then is moved through vapor in the second.

A second selection is a vapor-immersion-vapor cycle. Here, the solvent level is held low in the first chamber, allowing the accumulation of oils and grease as in a one-dip concentrator. The conveyor moves through hot solvent in the second chamber and then through solvent vapors in the final phase.

The boil-rinse-vapor cycle cleans the work in solvent at a boil temperature, at a rinse temperature and in the vapor. Some contaminants can be removed in vapor alone. These various phases can be recombined to form new cycles for special degreasing jobs.



These roof ventilators are but one of many applications for ENDURO Stainless Steel in the textile and chemical processing industries. Others include dyeing machines, vats, tanks, agitators, autoclaves, condensers, evaporators, valves and tubing.

Enduro Pays in many ways

Among the major reasons why Republic ENDURO Stainless Steel is a "natural" material for chemical and textile processing applications is its inherently high resistance to rust and corrosion.

Consider the case of these textile dyeshop roof ventilators. When made of ordinary steel, the high cost of replacing corroded ventilators every six months was dwarfed by the costly annoyance of rusty drippings which contaminated dyes and damaged materials.

After they were made of long-lasting ENDURO, however, these ventilators ceased being a source of constant maintenance and replacement expense. Rusty drippings were ended.

Perhaps you, too, have applications in which this and other ENDURO advantages effectively can reduce operating overhead. Talk to your equipment manufacturer, or write us for complete information:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
GENERAL OFFICES: CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

MID AMERICA EXPOSITION CLEVELAND

Republic ENDURO STAINLESS STEEL
Reg. U. S. Pat. Off.

REPUBLIC STEEL SERVES THE WORLD

Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Meetings and Expositions

NATIONAL MARINE EXPOSITION. New York, N. Y. May 20-25, 1946.

AMERICAN IRON & STEEL INSTITUTE, general meeting. New York, N. Y. May 23, 1946.

SOCIETY OF AUTOMOTIVE ENGINEERS, semi-annual meeting. French Lick Springs, Ind. June 2-7, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Aviation Division meeting. Los Angeles, Calif. June 3-6, 1946.

AMERICAN SOCIETY OF HEATING & VENTILATING ENGINEERS, semi-annual meeting. Montreal, Canada. June 10-12, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Oil and Gas Power Division meeting. Milwaukee, Wis. June 12-15, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. Detroit, Mich. June 17-20, 1946.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Division meeting. Buffalo, N. Y. June 21-22, 1946.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Buffalo, N. Y. June 24-28, 1946.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, corrosion conference. Gibson Island, Md. July 15-19, 1946.

Plants and Slants

The *Chicago Flexible Shaft Co.* has changed its name to *Sunbeam Corp.* The *Stewart Industrial Furnace Div.* will be redesignated the *Sunbeam Stewart Industrial Furnace Div. of Sunbeam Corp.* The company is developing new types of standard electric and gas-fired furnaces, including gas carburizing and nitriding types, and recirculating draw chambers. A smaller furnace with wide range of temperatures, gas-fired, and suitable for tool room use, is also in process.

The *Carpenter Steel Co.*, Reading, Pa., has announced plans for a modern new research laboratory. On the first floor will be experimental melting and rolling equipment, a heat treat department, machine shop and physical testing laboratory. On the second floor will be a complete metallographical laboratory, while the third floor will house the chemical laboratory, including equipment for spectrographic work. There will be conference rooms and a library.

Cash awards totaling $156,658 were paid by the *General Electric Co.* last year to employees whose ideas for improved plant and office operation were adopted. A total of 13,420 suggestions by employees for improved productions were adopted

from the 30,204 ideas submitted. Nearly $2,000,000 has been paid by the company since the plan was reorganized in 1922. The highest single award of 1945 was $1,365, involving the use of a pneumatic hammer for forming sheet metal.

The *Joslyn Mfg. & Supply Co.* has been licensed by *Inland Steel Co.* to produce stainless Ledloy steel at its Fort Wayne, Ind., plant. The process involves introducing of lead into steel for increasing machinability.

American Brake Shoe Co. announces a new $12,500,000 improvement and expansion program. Five of the seven new plants are foundries: A brake shoe plant, one for special iron castings, one producing alloy steel and two nonferrous foundries. There will be a new nonmetallic processing plant in this country, and one in Canada. A laboratory for research in automotive and industrial friction materials is under construction.

Metal Control Laboratories, 1220 Maple Ave., Los Angeles 15, announces the purchase of the cold treating business of the Green-Penny Co. which they are now operating as their cold-treating division, located at the plant of the Commercial Heat Treating Co., 970 S. Alameda St.

The *Hungerford Plastics Corp.* has been formed with plant at Murray Hill, N. J., to provide a complete thermoplastic service, including product and mold design, mold manufacture, material compounding, and facilities for injection and extrusion molding.

Volta Redonda, largest steel plant in Latin America, was scheduled to start production in Brazil in March. Initial output will be 300,000 tons yearly.

General Electric Co. has materially expanded its research staff at Schenectady to study the basic physics of atomic power. Already 20 scientists who were engaged on the Manhattan district project were with G. E., with 14 new appointments just announced. At least 60 will eventually be working in this field.

Bowser, Inc., Refrigeration Div. has been moved to enlarged facilities from Woodside, L. I., to Terryville, Conn. Production is in progress on industrial refrigeration units of the plug-in type for below zero steel treatment and shrink fit assembly work.

Called an "Easy-Chair Trip Through a Modern Steel Foundry" is a beautiful new brochure issued by the *Scullin Steel Co.,* St. Louis. The official title is: "100 Acres of Skill and Steel—a Visit to Scullin Steel Co., St. Louis."

The *Reynolds Spring Co.* occupied its new plant in Trenton, N. J. on Mar. 26. The large expanse of window and the one-story construction are modern trends incorporated into the building.

The *Barium Steel Corp.* has purchased control of the Central Iron & Steel Co., Harrisburg, Pa.

Reynolds Metals Co. has formed an ingot division with headquarters in Louisville, Ky., for production and sale of virgin aluminum and casting alloy ingot as well as aluminum deoxidizers for the steel industry.

Breeze Corporations, Inc. has purchased for cash the Anderson Stove Co., Inc. and Foundry Service, Inc., both of Anderson, Ind.

The manufacturing and engineering facilities of the *B. F. Sturtevant Co.*, purchased by Westinghouse in September, 1945, are being integrated with the facilities of the Westinghouse Air Conditioning Div., which has been transferred from Jersey City to the Sturtevant main plant at Hyde Park, Boston.

Colvilles, Ltd., Glasgow, Scotland, has been licensed to manufacture "Cor-Ten," corrosion-resistant, high strength, low-alloy steel developed by Carnegie-Illinois Steel Corp.

Frank C. Cheston, formerly sales agent for the Berwick heaters of *American Car & Foundry Co.*, New York, has taken over the rights to make and sell such electric metal heaters in the name of his own company, *Frank C. Cheston Co.*, 38 Park Row, New York 7.

Rheem Research Products, Inc. has moved its manufacturing and sales facilities to 4004 East Monument St., Baltimore 5.

House Organ Notes

The Power Specialist, Johns-Manville Co., Jan.-Feb., 1946

The interior of a broadcasting studio of the National Broadcasting Co., Radio City, New York, is a striking example of the part acoustical treatment plays in effective broadcasting. To the layman the large circular bumps, like blisters, the ceiling with its deep angles, the walls which are broken up into a combination of angles, with a minimum of flat surfaces, present an almost "Martian" appearance. These devices are to diffuse the sound, reduce reverberation and make operating conditions easier and more effective. Johns-Manville engineers furnish designs and material, "Transite."

Pig Iron Rough Notes, Sloss-Sheffield Steel & Iron Co., Winter, 1946

The scene is China. A dozen flickering, glowing fires are heading in the dusk towards the dock of the iron and steel works. One rower is singing a hunting song, while the others join in the wild refrain in time to the long oars, as they pull the heavily loaded sampan to a mooring place. Over each glowing fire is an iron rice-bowl, large enough to hold a meal for the hungry crew. The bowls are 2 to 3 ft. across, not over 1/8-in. thick. They are a triumph of the iron caster's art and have been made by the Chinese country foundries since time immemorial. By nature the foundryman of China is an artist, a perfectionist—and not a mass production man. The larger blast furnaces melt from 10 to 20 tons per day and make excellent pig iron.

Lead, Lead Industries Assn., Jan.-Feb., 1946

The art of making fine glassware has for centuries been regarded as one of the most honored crafts, but until George Ravenscroft in 1676 successfully produced lead glass, the maximum possibilities of the

PHOTO COURTESY OF THE BETTMAN ARCHIVE

FROM A METAL MAKER'S FAMILY ALBUM

WHEN OPEN HEARTH STEEL WAS AN INNOVATION—

"Standard" Was Doing Business at its Present Stand

This picture, drawn in 1876, shows a busy time at the pouring pits. It's possible that the metal came from one of the early open hearth furnaces, for they had recently been introduced in America.

Always a pioneer, Standard Steel quickly recognized the commercial advantage of the new steel, discontinued the operation of its crucible plant, and began to manufacture tires from open hearth steel.

Today Standard's foundry has an annual capacity of 20,000 tons, a forge shop capacity of 15,000 tons of locomotive forgings, plus 30,000 tons of heavier miscellaneous forgings.

You'll find complete facilities to handle all classes of your work promptly and accurately at Standard. To simplify your buying why not "Standardize on Standard."

BLW THE BALDWIN GROUP

BALDWIN

FORGINGS AND CASTINGS

The Baldwin Locomotive Works, Standard Steel Works Division, Burnham, Pa., U.S.A. Offices: Philadelphia, New York, Chicago, St. Louis, Washington, Boston, San Francisco, Cleveland, Detroit, Pittsburgh, Houston, Birmingham, Norfolk.

"STANDARDIZE ON STANDARD" FOR YOUR FORGINGS AND CASTINGS

glass maker's art could not be realized. Ravenscroft found that by substituting lead for lime in the mix he could produce a glass of great clarity and brilliance that had vastly improved working qualities. Crystal glass should be absolutely transparent, colorless and free of imperfections. Only with lead and careful technique are these possible. Such glass is so highly refractive as to be alive with light. It rings like a bell when struck. In the form of litharge, the lead is mixed with sand, potash and cullet (broken glass) and melted in clay pots. The resultant glass is worked at 1800 F.

Briggs Assembler, Briggs Mfg. Co., Jan.-Feb., 1946

Here is how new beautiful radiator grills and glistening body moldings for automobiles are made at the Eight Mile Plant, Detroit, of Briggs. Stainless steel stock arrives at the plant in huge coils, varying in width and thickness, depending on the final use. In the rolling department it is machine rolled into different forms, one into belt moldings for car bodies and the other into radiator grill molding strips. An automatic buffing machine gives them a high natural metal gloss. Then each strip is cut into exact sizes on a machine. Each strip goes through ten press operations to receive the desired shape; then to the assembly department where fastener clips and brackets are spot welded to them. Then they pass through 150 and 220 emery grit oil polishing wheels; then through a cloth buffing wheel, where a luster compound is applied.

Ceramic Forum, O. Hommel Co., February, 1946

Ceramic engineers recently visited Germany and brought back interesting samples of German ceramic craft. Among them is a very fine example of precision extrusion of steatite; also regular steatite insulators, floor and wall tiles, alumina parts made of pure alumina fired to 1850 to 1950 C and a section of a slipcoat porcelain homestyle radiator. These radiators are common in Germany because of the metal shortage. They may continue as standard equipment because of good appearance and cleanliness that offsets lower conductivity.

Aluminum News-Letter, Aluminum Co. of America, March, 1946

Alcoa's aluminum research laboratories have been using the electron microscope for the past few years. Aluminum and its alloys are unique, however, in that very thin oxide films of a type suitable for electron microscope specimens can be formed on the surface of the samples to be examined by an electro-chemical treatment. These films can be removed and used for examining the metal structure with the electron microscope. Instead of making a reproduction of the metal surface as is done in the replica methods, the actual metal surface is changed into an oxide film only two-millionths of an in. thick. This film, 1 lb. of which would cover an area of 33,000 sq. ft., is then stripped from the aluminum and used as a specimen in the microscope.

Television Broadcast News, Radio Corp. of America, January, 1946

A hitherto secret television camera tube of revolutionary design and sensitivity was recently demonstrated by R.C.A. It not only

can transmit scenes illuminated by candle and match light, but can even pick up scenes with infra-red rays in a blacked-out room. Called the Image Orthicon, it makes possible 'round-the-clock coverage of news and special events. It provides greater depth of perception and clearer views under shifting light conditions than former tubes. In fact, it is 100 times more sensitive than conventional pick-up tubes.

Grits and Grinds, Norton Co., January, 1946

Among the war "Now It Can Be Told" stories is that of cutting bullet resistant glass for windows of bombers. This glass varied from 1½ to 3½ in. in thickness and contained from 5 to 9 plies of glass with a strip of clear plastic between each ply. The roughly cut edges had to be ground accurately. At first silicon carbide abrasive wheels, commonly used for grinding glass, were used. But they wore out in 4 days and cut slowly. At length, an 80-grit metal bonded diamond wheel was used, the first wheel lasting 4 months and being capable of taking up to 1/32-in. depth of cut per pass at the phenomenal table speed of 90 in. per min.

News of Engineers

R. E. Ward has succeeded *Dr. Norman E. Woldman* as chief metallurgical engineer, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J. Dr. Woldman resigned from Eclipse-Pioneer on March 15 to establish his own consulting engineering firm, Norman E. Woldman, Inc., Upper Montclair, N. J.

Carroll L. Wilson, executive assistant since 1942 to Dr. Vannevar Bush, director, Office of Scientific Research & Development, has been elected vice president, National Research Corp., Boston. Recently he has been serving as secretary to the Department of State's Board of Consultants on atomic energy. At one time he was head of Institutional Patents Div. of Research Corp.

Walter L. Longnecker has been made division superintendent of the rod mills in the Cuyahoga Works, American Steel & Wire Co. He joined the company in 1939 and in June, 1945 was made division metallurgist, rod mills, with offices in Cleveland.

Clarence A. Norris has become chief chemist, Eaton Mfg. Co.'s stamping division at Cleveland, and will be in charge of the plating department in which bright nickel and chromium plating and general rustproofing are performed on automotive parts. When with U. S. Rubber he had charge of metal-to-metal adhesion through brass plating.

Roger F. Mather has been made chief metallurgist, Kaiser-Frazer Corp. and Graham-Paige Motors. Formerly chief metallurgist at Willys-Overland Motors, he was in charge of specifications and testing of all materials in the "Jeep."

Leland E. Householder is now chief metallurgist of the Grand Rapids, Mich., extrusion plant recently acquired by the Reynolds Metals Co. He worked on the

development of R-303 aluminum alloy and was once with the American Sheet & Tin Plate Co.

Paul Abel, formerly assistant chief engineer of the Yoder Co., designer and manufacturer of special metalworking machinery, has been appointed chief engineer. During the war he took charge of Yoder's gun and shell production.

Joseph F. Libsch has been engaged as a consulting metallurgist by Lepel High Frequency Laboratories, Inc., New York. As a member of the faculty at Lehigh University, he explored the metallurgical aspect of induction heating. He has spent over 4 years at Springfield Arsenal in metallurgical research on steel used in small arms.

Harry Wilson, Jr., formerly vice president in charge of operations, Jessop Steel Co., has been elected first vice president. He has been with Jessop for 40 years, other connections having been general superintendent and works manager.

J. Eugene Lindsay has rejoined the research department, Plastic Metals Div., National Radiator Co., after over four years with Chemical Warfare Service, U. S. Army. The company makes iron and other metal powders.

Thomas F. O'Brien has been made metallurgist with Kali Mfg. Co., Philadelphia, and will have charge of sales and engineering on metallurgical chemicals.

E. W. Huseman has joined the metallurgical staff of La Salle Steel Co., Chicago, where he will engage in metallurgical and engineering development prospects. He has previously been metallurgist with the Copperweld Steel Co. and Republic Steel Corp.

R. H. Davies has been made consulting engineer in charge of the educational work of the Lincoln Electric Co., Cleveland. He was stationed at Washington in recent years to give advice on welding problems to government agencies. He was plant engineer in the building of Kaiser's large magnesium plant, etc. at Permanente, Calif.

Howard H. Wilder has been made chief metallurgist of the foundry division of the Eaton Mfg. Co., having formerly been research metallurgist, Wilson Foundry Machine Co., Pontiac, Mich. Other experience has been with Vanadium Corp., Detroit Stoker Co., and Chevrolet Gray Iron Div. During the war he served with the Gray Iron Foundry Section, WPB, at Washington.

Dr. F. R. Hensel has been made vice president in charge of engineering, P. R. Mallory & Co., Inc., Indianapolis, having been chief metallurgical engineer for that company since 1934. He holds degrees from several European universities, is a member of several technical societies, has presented over 40 technical papers before technical groups and has been granted over 140 patents on alloys and metallurgical processes.

Lars E. Ekholm has joined the metallurgical engineering staff of the Climax Molybdenum Co. He has had similar experience with the Aluminum Co. of America, Harrisburg Steel Corp., Henry Disston & Sons, Inc., and Alan Wood Steel Co. He has been active in technical society work and helped develop NE and H Steels.


STEWART
INDUSTRIAL
FURNACES
SPENCER
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Since 1921

Dr. Bruce S. Old has joined Arthur D. Little, Inc., Cambridge, Mass., to engage in metallurgical research. Before serving with the Navy as commander he was with Bethlehem Steel Co.

Albert J. Hulse, formerly with Carnegie-Illinois Steel Corp., has joined the Youngstown Sheet & Tube Co. as chief engineer, succeeding J. D. Jones, who left the company a year ago.

Briefs on Associations, Promotions and Education

At a meeting of the Southern California district committee of the American Society for Testing Materials at Los Angeles in March, J. R. Townsend, New York, president, and C. L. Warwick, Philadelphia, executive secretary, told of the plans of the society to expand its activities to cover consumer goods as well as industrial products. The new scope will cover stockings, fabrics, gasoline, oil, etc., such as used by the average small consumer.

The first national instrument show under auspices of the Instrument Society of America will be held on the 17th floor of the William Penn Hotel, Pittsburgh, Sept. 16 to 20. The exhibit will show the latest development in industrial and scientific instruments for research, analysis, measurement, control, inspection and testing. Besides the technical meetings, short courses will be held at the Carnegie Institute of Technology under Dr. B. R. Teare, Jr., head of the electrical engineering department.

The second National Electronic Conference sponsored by the Illinois Institute of Technology, Northwestern University and the Chicago sections of AIEE and IRE, with the cooperation of the Chicago Technical Societies Council and the University of Illinois, will be held at the Edgewater Beach hotel in Chicago Oct. 3 to 5.

A Pacific Research Foundation is being organized, with headquarters at Palo Alto, Calif., in connection with Stamford University. Meanwhile, the organizers are lining up research projects, which will determine which departments of the Foundation will be built up first. Aircraft engineers had been working for this project for a long time. Presumably it will work along the lines of Battelle Memorial Institute. Assisting in the organization is Dr. Henry T. Heald, head of Armour Research Foundation.

The Decorative Moulding Council, national association of manufacturers of metal and plastic moulding for home furnishings, has elected as managing director A. V. Fingulin, with headquarters at 630 Engineers Bldg., Cleveland 14.

S. C. Massari has been appointed technical consultant of the American Foundrymens' Assn. He was recently awarded the Legion of Merit for his work in the Chicago Ordnance District. In the absence of N. F. Hindle, technical development program director, he has been arranging the Associations' Golden Jubilee Congress in Cleveland May 6 to 10.

Heli-Coils are precision-shaped helical coils of stainless steel or phosphor bronze, engaging exactly with American National threads. They are available in all sizes from No. 8 up. They are also furnished for 10, 14, 18 mm and ⅞" spark plugs.

Heli-Coils are ideal for maintenance work. They make a sound permanent repair of stripped and worn threads in cast and molded materials. They are much lighter, stronger, and more compact than solid bushings, and are easily and quickly installed. They allow use of the *original* size screw or stud.

HELI-COIL Inserts are being used in large quantities to prevent wear and damage to tapped threads. Millions were used during the war and are being used in U.S. aircraft engines both as original parts and for maintenance. Wherever threaded parts are disassembled frequently—or where there is unusual stress or vibration—Heli-Coil Inserts *strengthen* the cast or molded parts and prevent wear. They provide a hard, tough bearing surface which prevents seizing, wear and damage.

ENGINEERING REPRESENTATIVES

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Donald McClain
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MID-EASTERN
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Margiyn Farm
Lone Fountain, Va.

KANSAS CITY
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Kansas City 8, Mo.

DETROIT
G. C. Brown and
A. W. Reader
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Royal Oak, Mich.

LOS ANGELES
J. S. Wise
Room 925—Pacific Mutual Bldg.
523 W. 6th St.
Los Angeles, Cal.

WRITE TODAY ***For Illustrated, Informative Bulletin No. 239***

AIRCRAFT SCREW PRODUCTS CO., INC.
47-23-G 35th Street
Long Island City 1, N. Y.
Please send me your Bulletin No. 239

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HELI COIL

AIRCRAFT SCREW PRODUCTS COMPANY, INC.
47-23G 35th STREET • LONG ISLAND CITY, 1, N.Y.

The British Institute of Metals platinum medal for 1946, one of the most coveted honors in the British nonferrous metals industry, has been bestowed upon its past president, Lt.-Col. Sir John Henry Maitland Greenly, K.C.M.G., C.B.E., M.A., chairman of Babcock & Wilcox, Ltd., in London. The honor was in recognition of Sir John's outstanding services to the nonferrous metals industry, and was voted unanimously by the Institute's Council.

"Testing Plastic Parts," the fourth chapter of the technical handbook developed by the Engineering and Technical Committee of the Society of the Plastics Industry, has become available from the Society at 295 Madison Ave., New York. It relates to tests given finished articles to ascertain their ability to stand up under consumer usage.

A colloquium of four lectures on powder metallurgy has been arranged by the College of Engineering of New York University, 181st St. and University Ave., Bronx, New York. The two remaining lectures are: May 24, "Principles of Sintering," Prof. Frederick N. Rhines, Carnegie Institute of Technology; June 14, "Principles of Pressing," Prof. John Wulff, Massachusetts Institute of Technology.

Battelle Memorial Institute has received its fifth award in recognition of its war service, this being a Naval Ordnance Development award by the Navy Bureau of Ordnance. Some 40 members of the Battelle staff also received individual awards.

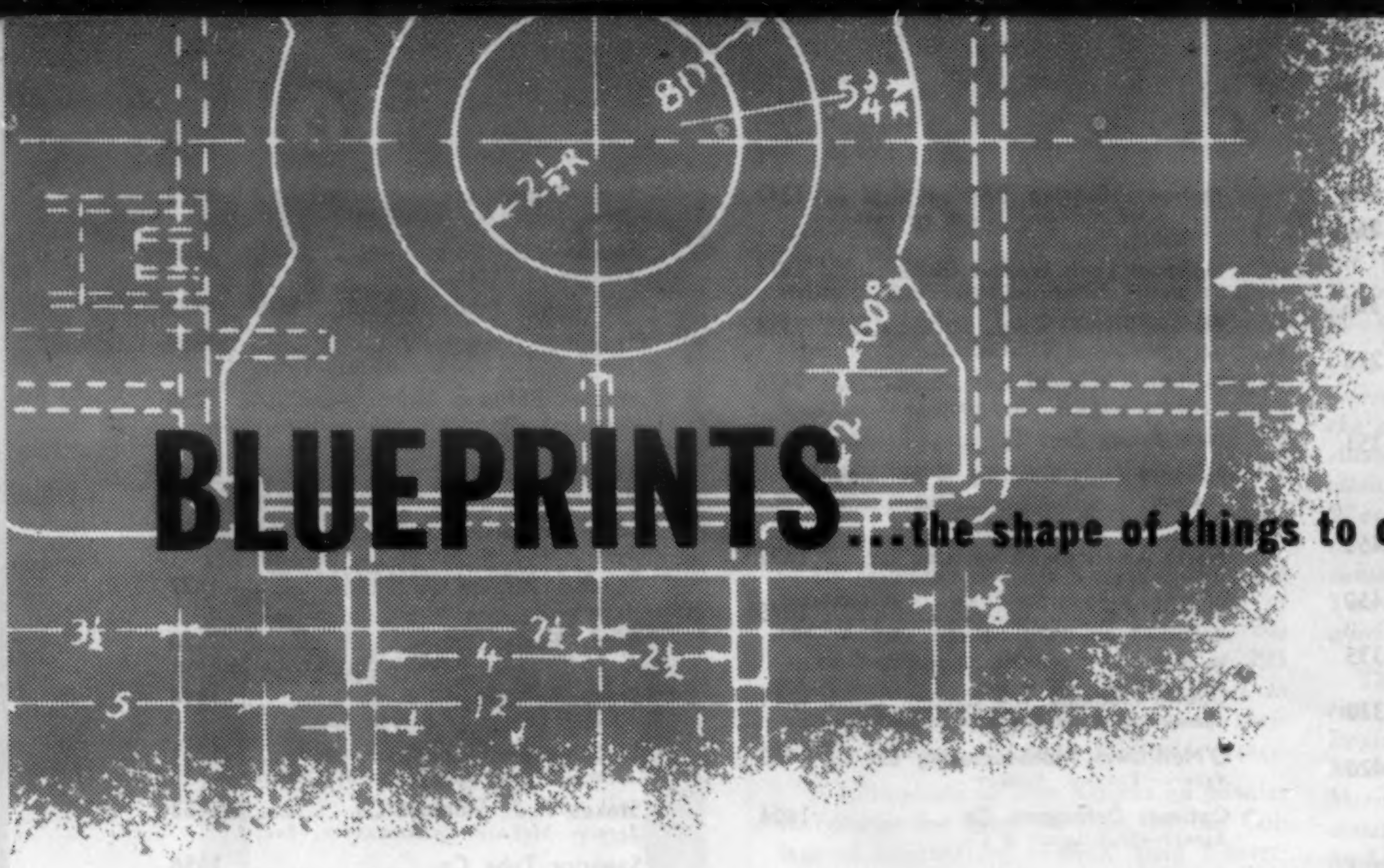
"Opportunities for Productive Work Through Mineral Industries Research" is the title of a well-illustrated booklet of Pennsylvania State College, State College, Pa., obtainable free.

A corrosion conference will be held at Gibson Island, Md., July 15 to 19, under the auspices of the American Assn. for the Advancement of Science. Applications to attend should be sent to Summer B. Twiss, Wayne University, Detroit 1. Various technical papers on corrosion and related subjects will be presented by ten experts. Two speakers will talk on high temperature alloys: Oscar E. Harder and W. O. Binder.

The semi-annual meeting of the American Society of Heating and Ventilating Engineers will be held June 10 to 12 at Montreal. The session will open at the Mount Royal Hotel and will continue aboard the cruise ship "Quebec" up the St. Lawrence.

"Metal Magic" is a full-color sound movie just produced by the Allis-Chalmers Mfg. Co. and dealing with induction heating. It runs 12 min., is for 16-mm. sound projectors only, and is available for showing before interested groups.

Among the new organizations is Southern Research Institute at Birmingham, Ala., which works with the natural resources of the South. The director is Wilbur A. Lazier, formerly with the du Pont Experimental Station, Wilmington, Del.



BLUEPRINTS...the shape of things to come

Electric Motor Made of Stampings

Within the near future we shall see a new electric motor that breaks from tradition in several ways and which will be smaller and weigh less than the conventional motor. Castings will be replaced by stamped and pressed steel parts welded together. Insulation on wires will be of synthetic resin. Latest machining methods will be used. It will meet all NEMA standards.

Future Metals for Aircraft

An authority on materials for aircraft has predicted for us a boom in the use of the following three classes of materials for airplanes: (1) aluminum alloys containing 6% zinc, 2.5% magnesium and 2% copper (Alcoa 75S and Reynolds Metals 303) as sheets, forgings, tubing and bar stock; (2) chromium, nickel, cobalt alloys for large forgings and castings for high temperature application; and (3) silver plating for wearing surfaces in engines and accessories.

New Non-Burning Magnesium

Magnesium alloys of the near future will be markedly superior. Recently an alloying addition has been devised that remarkably inhibits its burning characteristics, making it equal to steel. Superior fluxes and improved metal-handling have eliminated harmful flux inclusions and promoted corrosion-resistance. Iron, copper, nickel and silicon are undesired impurities affecting salt atmosphere corrosion resistance, but by production control methods these impurities are now kept low enough.

And "Mag" with Other Better Qualities

Through new technology, magnesium castings made from low-impurity metal will be available commercially. The low, or zero, zinc-containing alloys may therefore be used as they have salt atmosphere corrosion resistance equal to higher zinc alloys. The low zinc alloys have better feeding characteristics, need fewer risers and are easier to heat treat than higher zinc alloys. Hence, we'll have cheaper and more corrosion-proof castings of very high quality. Former "mag" alloys deteriorated at 250 F; the newer ones stand 600 F, and laboratory stage alloys will do even better. There are improvements in the offing regarding anodic coatings, paint systems, forming and welding techniques and resistance to stress-corrosion cracking. Methods for cladding magnesium sheet are about ready for commercial output.

Aluminum Boat for Outboard Motor

With the boating season full upon us and office claustrophobia making itself felt in a critical form, we've got to talk about the small aluminum boat that is proving itself. Now the wooden small boat for outboard motor absorbs 20 to 25% of its weight in water each year. It needs constant caulking, painting and safeguards against rotting. As to aluminum—they'll take a single sheet of 0.064 gage aluminum alloy, put it in a 1700 ton press and turn out a 12-ft. craft with a 54-in. beam, with practically no draft and carrying six men. Dents are smoothed with wooden mallets. Any holes in the hull are repaired by welding. Painting is optional—it will be anodized for salt walter. Electrolytic action between hull and bronze propeller is eliminated by wooden clamp pads. It will have the "scow bow" of wartime assault craft. Ship ahoy there, skipper!

Black-Out Plants

"Black-out plants," without windows and with strict air-conditioning and humidity control, are by no means a trend and may be chalked down as a dubious experiment. In the war of the future the vital plant must be placed under ground where it will be automatically blacked out. Such a plant on the earth's surface promotes a noticeable restlessness and let-down of morale among day-shift workers, especially in warm, balmy weather which is not ameliorated when hourly bulletins of weather conditions are posted on bulletin boards. Extra investment, of course, has been placed in air-conditioning equipment, but it is not justified because of offsetting unfavorable factors, according to the experts. Where the black-out plant may continue will be in certain precision manufacturing operations.

Perpetual Motion (?)

A principle developed in a clock to be marketed is about as close to perpetual motion as the human race has yet accomplished. The power is based on changes of temperature. The clock's springs will be wound by a bellows actuated by temperature change. One degree change in temperature can assure 120 hr. of clock operation.

"No-Carbon" Stainless Steel

A new answer to the problem of carbide precipitation in stainless steels may be found in a still experimental but extremely promising stainless steel containing less than 0.03% carbon on which one large company is now working. This amount of carbon is within the carbon solubility range, hence stabilization would not be required to prevent carbide precipitation during processing or use.

Welded Locomotive Boilers

Apparently welded boilers for locomotives will become universal—give the idea another few years. Riveted joints are likely to have some seepage between the boiler plates; by welding there is less danger of cracked sheets, which are often a major item of maintenance cost; welding provides a smooth contour of the boiler, permitting a better application of the boiler lagging and jacket and more satisfactory washouts; a saving of weight runs from 3000 to 6000 lb. for the boiler alone, besides some saving in lagging and jacket. A D & H locomotive, with welded boiler, has been in service 6½ yr. with no shell repairs.